LEVEL II

3

MOBILITY EQUIPMENT RESEARCH & DEVELOPMENT COMMAND

U.S. ARMY MOBILITY EQUIPMENT RESEARCH & DEVELOPMENT PLAN

FORT BELVOIR, VA

MARCH 1981

Mobility Equipment Research & Development C

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RESEARCH AND DEVELOPMENT

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FOREWORD

This Research and Development Plan addresses the US Army's need for mobility equipment to satisfy combat support, mine warfare, and combat service support functions. The Plan identifies deficiencies in current and projected near term operational capability and describes the Science and Technology Base Program applicable to the Mobility Equipment Research and Development Command, Ft. Belvoir, Virginia.

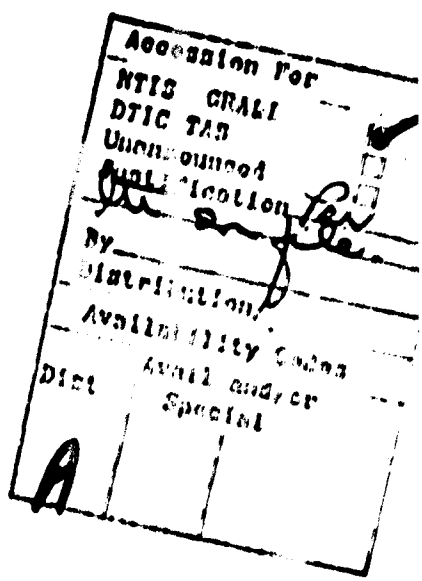

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

CHAPTER I
INTRODUCTION

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INTRODUCTION

A. PURPOSE

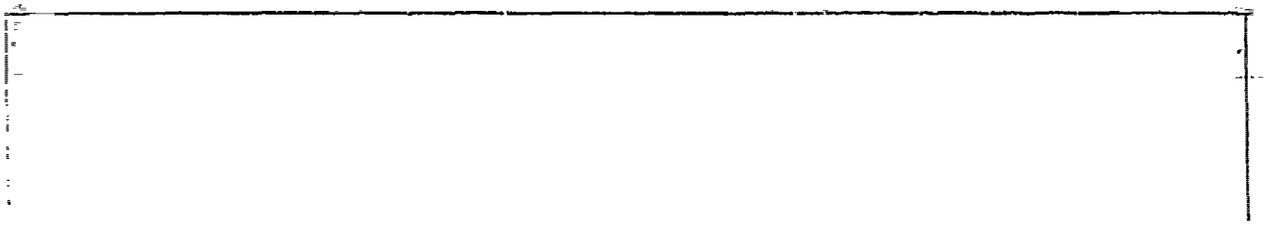
The purpose of this plan is to present an overview of the Mobility Equipment Research and Development (R&D) Program. The plan focuses on the Science and Technology (S&T) Base Program and the technology products it will provide to tactical units relative to deficiencies in operational capability. A deliberate functional analysis approach has been followed to insure exhaustive examination of the responsiveness of current materiel and near-term materiel acquisition to operational requirements in light of the projected threat. Deficiencies identified by this approach are created as high priority areas for support by the S&T program. This plan is a companion document to both the DARCOM Long Range RDA Plan, which addresses the next higher level of the planning hierarchy, and to a set of equipment digests which describe the current materiel and near-term materiel acquisition items. The plan is a living document and will be used to enhance dialogue between the user and the material development community. This is part of the joint DARCOM-TRADOC initiative in long range RDA planning. It also contributes to the DARCOM initiative for increased corporate interaction and involvement in shaping the DARCOM S&T Base Program. Comments on the plan are welcome and should be directed to the following address:

Commander
US Army Mobility Equipment R&D Command
Attn: DRDME-US
Fort Belvoir, VA 22060

The MERADCOM mission includes mobility, survivability, energy and logistic support required for the Army to concentrate and fight on the modern battlefield. R&D activity is further delineated and organized within nineteen fields of endeavor (FOE) as shown in Figure I-1.

B. BACKGROUND

Modern warfare, as characterized by the tactics of potential adversaries of the United States, consists of localized power concentration, penetration and follow through by insertion of a second echelon force. This creates a battlefield environment where the forward edge of the battle ar is constantly changing. As a result, highly mobile armored equipment and highly capable dry and wet gap bridging systems have been developed by the Soviet and Warsaw Pact forces. Also as part of their tactical approach, various types of battlefield obstacles and area denial systems have been developed. To counter these



COMBAT SUPPORT, ENGINEERING AND MINE WARFARE

COMBAT SERVICE SUPPORT

MOBILITY	SURVIVABILITY	ENERGY	LOGISTICS
● BRIDGING	● FIELD FORTIFICATIONS	● ELECTRIC POWER	● WATER SUPPLY
● COUNTER-MINE	● CAMOU-FLAGE	● FUELS AND LUBRICANTS	● FUELS HANDLING
● CONSTRUC-TION EQUIP-MENT	● PHYSICAL SECURITY	● HEATERS AND AIR CONDITION-ERS	● MATERIALS HANDLING EQUIPMENT
● BARRIERS	● TUNNEL DETECTION		● MARINE CRAFT
	● TOPO-GRAPHIC EQUIPMENT		● UTILITY EQUIPMENT
	● TACTICAL SENSORS		● RAILWAY EQUIPMENT

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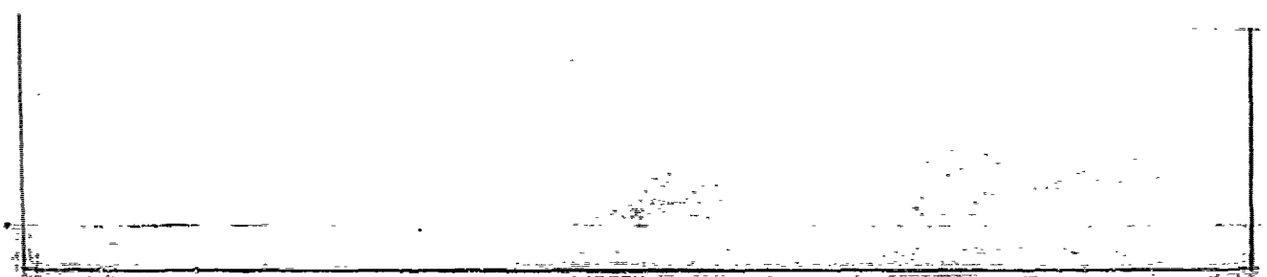
Figure I-1. Fields of Endeavor



tactics, superior US and allied force mobility is required. Combat units must be capable of moving rapidly. Certain types of defensive activities, such as establishing survivable positions and emplacing minefields, must be conducted far more quickly than current equipment permits. Friendly force mobility and tactical flexibility must be maintained by locating and clearing minefields, crossing obstacles, breaching gaps and neutralizing area denial efforts of opposing forces. Defensive efforts must take on an "active" character by deploying minefields and preparing large and small entrenchments rapidly, and constructing shelters and fortifications for defensive positions. Logistic support equipment must be adequate to insure that fuel, ammunition and other military essential supplies are available in sufficient quantities to support the maneuver force. The continuing decline in the supply of petroleum-based fuels requires that military standards and specifications be evaluated and revised if necessary to insure that equipment will be compatible with the fuels and lubricants that will be available in the future. A further urgent Army need exists to satisfy both the increasing demands for mobile electric power and the need for more efficient energy usage. Future generators must be lighter in weight, more efficient and reliable, and have less prominent thermal and acoustic signatures.

The responsibility for the development of materiel to meet these needs in combat support and combat service support is almost exclusively that of MERADCOM.

C. METHODOLOGY

As an R&D manager, USAMERADCOM is continually confronted with the problem of distributing limited resources among a large number of complex and comparatively diverse fields of endeavor. The decision making process in this regard must maintain the proper relationship of technical program efforts with respect to all of the practical and operational characteristics of user requirements in a strictly functional sense. The normal activities surrounding the contributions made by the materiel developer within the Army Materiel Acquisition System tend to be conducted primarily in an atmosphere of applied research, engineering and technology. As such, there is a tendency for these activities to veer away from the realities of the battlefield and resulting military requirements upon which any R&D effort should be based. Judicious use and application of military worth analyses at critical decision points of the R&D process facilitates the transfer of operational requirements into realistically conceived and executed items of military hardware and systems. Over the past several years,

military worth evaluations have been conducted on concepts and developmental items within our mission area. As a result of these studies, a need has become apparent to further improve the lines of communication between the materiel developer and the user. In order to facilitate this interplay and understanding, a detailed review of each FOE was conducted. Current deficiencies were identified by comparing current and developmental capabilities against anticipated needs. The S&T base program was structured to address these deficiencies. This approach is diagrammed in Figure I-2.

D. DESCRIPTION OF PLAN

This plan identifies and describes key elements in fifteen fields of endeavor. Each chapter is structured in a similar fashion, opening with a statement of military significance for the FOE and continuing through functional characteristics, current Army capability, present acquisition activities, current deficiencies in capability and concluding with the S&T base program. Of the nineteen fields of endeaver shown in Figure I-1, four are not described separately. These are Barriers, Topographic Equipment, Utility Equipment, and Railway Equipment. S&T activity supporting Topographic Equipment is the responsibility of the Engineer Topographic Laboratory. Advanced topographic concepts are transferred to MERADCOM for Engineering Development. S&T activities in Barrier-related items, utility and railway equipment are discussed with associated FOE's rather than being described separately. Fire Fighting Equipment is included in the Utility Equipment FOE together with various items and collections of equipment used for field maintenance and servicing.

The individual chapters are structured as follows:

1. Military Significance and Need

A statement describing the military operations that can be performed with the materiel items of the associated FOE.

2. Functional Characteristics

A listing of the functions and activities necessary to accomplish the military missions that are normally associated with the FOE.

3. Current Capability

A description of current and projected near-term capability in the Army which satisfy FOE functional requirements with emphasis on major items of equipment. This section is accompanied by a chart showing baseline equipment and their relationship to the FOE functional areas.

4. Acquisition Activities

Current acquisition activities (Advanced Development (6.3b), Engineering Development, Product Improvements,

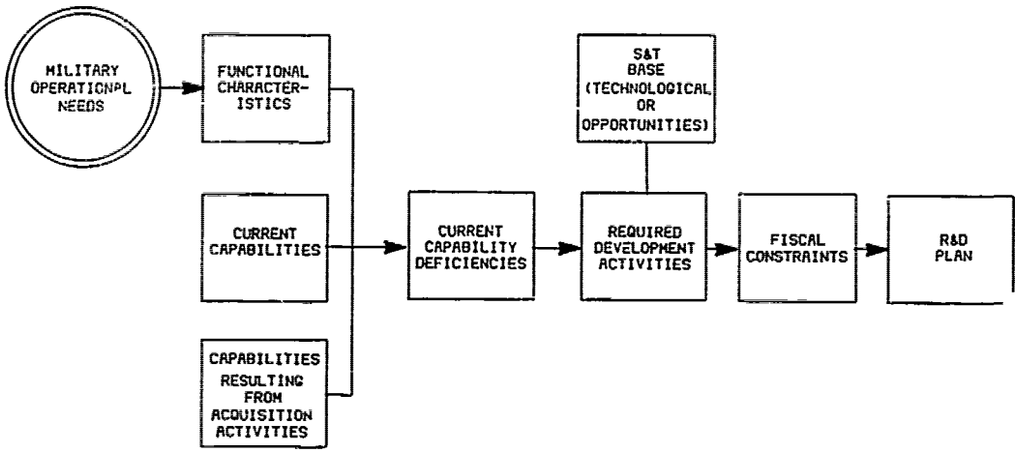
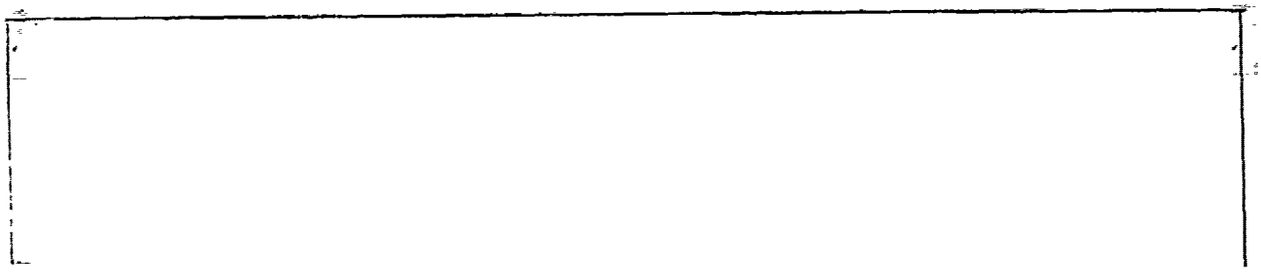


Figure I-2. Methodology Flow Chart



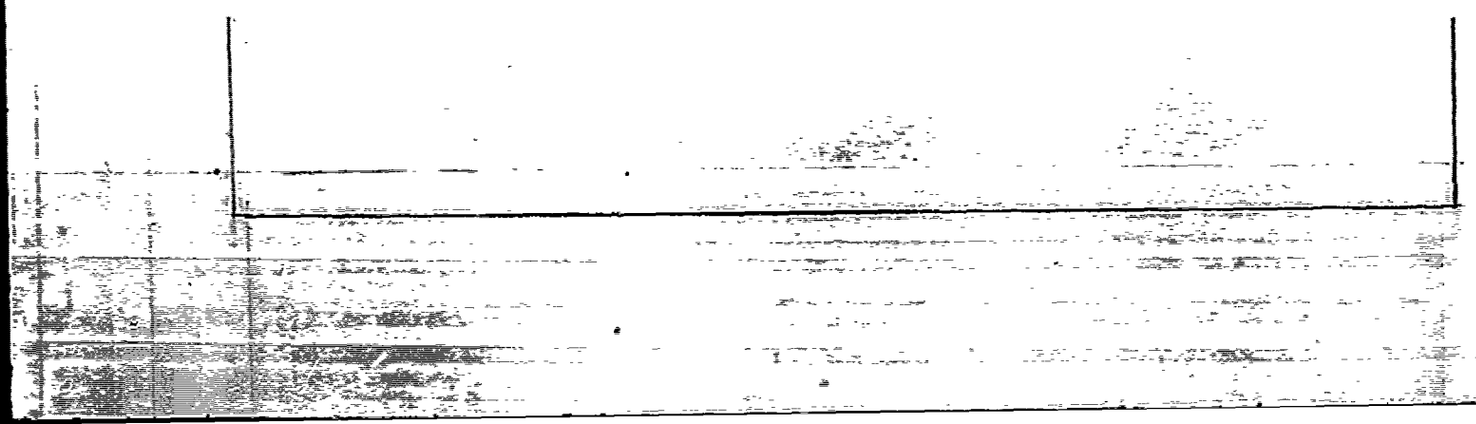
etc.) are described which will provide new or improved equipment in each functional area. A chart relating the acquisition activities to the functional areas is included. The accompanying text describes the systems or items of equipment under development that are in the acquisition phase.

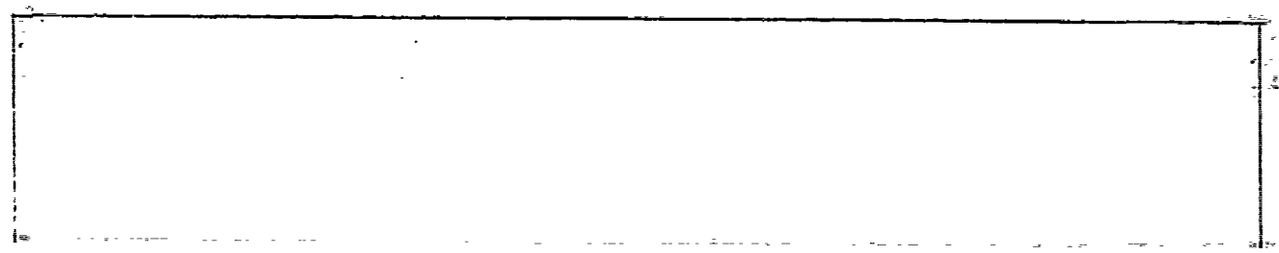
5. Current Capability Deficiencies

Capability deficiencies arrived at by comparing current and developmental capabilities with functional requirements are described in this section. Consideration is given to changing battlefield conditions, stated strategic and tactical plans and emerging new military concepts (Rapid Deployment Force). Deficiencies parallel those cited in the DARCOM Long Range RDA Plan.

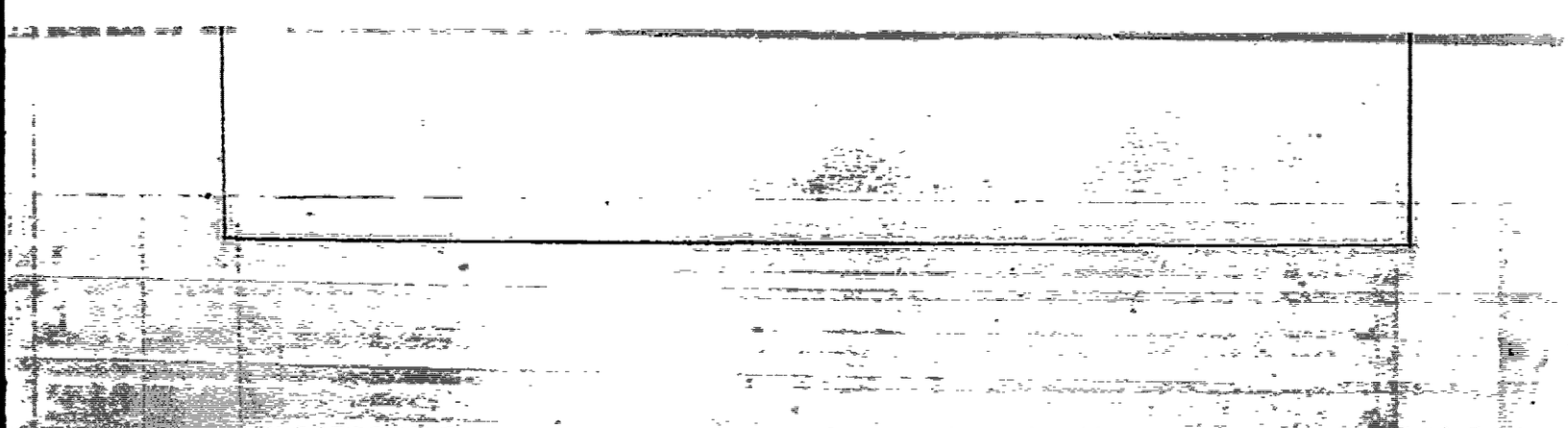
6. Science and Technology Base Program

The final section of each chapter is a description of the Science and Technology Base Program which supports the FOE. The section commences with a discussion of technologies involved, technical approaches, recent research efforts, developmental problems and risk. The section concludes with a listing and description of the S&T Base Program products and activities. Accompanying this is a chart showing each deficiency, the technology products designed to correct this deficiency, and the schedule and funding profile. The funding profile illustrates projected funding for fiscal years 1981 through 1987 in the 6.1, 6.2 and 6.3a funding categories. For fiscal years 1981 through 1983, an unfunded category is shown where appropriate (shaded column).





CHAPTER II
BRIDGING



CHAPTER II

BRIDGING

A. MILITARY SIGNIFICANCE AND NEED

Military bridging defeats both natural and threat produced barriers enabling US forces to maneuver decisively in order to concentrate, fight and win on the integrated battlefield.

Bridges are positioned and used for crossing wet and dry gaps in three general situations: under enemy fire; for temporary tactical mobility; and for long-term logistical support.

B. FUNCTIONAL CHARACTERISTICS

Military bridging can be divided irto the following four major functional areas.

1. Assault Bridging

This function involves the transport and emplacement of bridging structures in the face of an active ground defense of the obstacle by the enemy. The principal subdivisions of this function are wet gap (e.g., river) bridging and dry gap (e.g., ravine) bridging.

2. Tactical Bridging

This function provides temporary bridging in support of tactical operations. It differs from assault bridging primarily in that it is not emplaced in the face of enemy ground fire. Tactical Bridging also differs in that it is normally feasible to emplace intermediate supports under the bridging. The principal subdivision of the function are Dry Gap Bridging, Wet Gap Bridging, and Ancillary Equipment. Ancillary Equipment encompasses the equipment that is not actually bridging but that is required to erect tactical bridging.

3. Lines of Communication Bridging

LOC Bridging is the provision of major permanent bridging constructed in the field by semi-skilled labor from pre-fabricated components. Such bridging is usually erected to replace destroyed peacetime bridging on major traffic arteries. The principal subdivisions of this function are Highway Bridging and Railway Bridging.

4. Other Gap Crossing Equipment

This function provides specialized military bridging from situations where the other classes of bridging are inappropriate. Typical examples of this function are the provision of aerial tramways and cableways for crossing obstacles in the mountains or jungle terrain where mobility limitations necessitate the use of extremely lightweight

bridging systems. The major subdivision of this function are Aerial Tramways, Cableways, and Trestles.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet its bridging requirements consists of the existing equipment presented in Figure II-1. Descriptions of each of these items are presented in Volume X of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing bridging capabilities are summarized below.

The primary assault bridging capability consists of the Mobile Assault Bridge (MAB), a Class 60 floating bridge which can be extended to any required length, and the Armored Vehicle Launched Bridge (AVLB), a Class 60 scissoring bridge which can span 60 feet. The primary tactical mobility bridging capability consists of the Ribbon Bridge, a Class 60 floating bridge which can be extended to any required length, and the Medium Girder Bridge (MGB), a Class 60 panel bridge (with tension reinforcing) which can span 100 feet. The primary logistical support bridging capability consists of a variety of sets of prefabricated civilian-type construction components tailored to rapid erection in the field by semi-skilled labor under competent supervision.

D. ACQUISITION ACTIVITIES

Figure II-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs. At present these are focused on wet and dry gap assault bridging and wet and dry gap support for tactical bridging operations. Two basic systems are affected by these acquisition activities. They are the rapidly emplaced mechanized bridge (REMB) with nine components presently under development and the launcher and M48A5 tank chassis for the Class 60 Armored Vehicle Launched Scissors Bridge (AVLB).

As part of the "Bridging for the 80's" program, the REMB is part of a family of bridges using common components for the assault; the dry gap, and the wet gap tactical support bridging operations. The system consists of a wheeled and an armored tracked transporting/launching vehicle. The tracked vehicle is used for assault operations, and the wheeled vehicle is used for support bridging operations. The launcher and M48A5 tank chassis for the Class 60 Armored Vehicle Launched Scissor Bridge provides an improved armored/tracked means to launch, retrieve and transport the Class 60 scissors bridge. Figure II-3 illustrates the rapidly emplaced mechanized bridge (REMB).

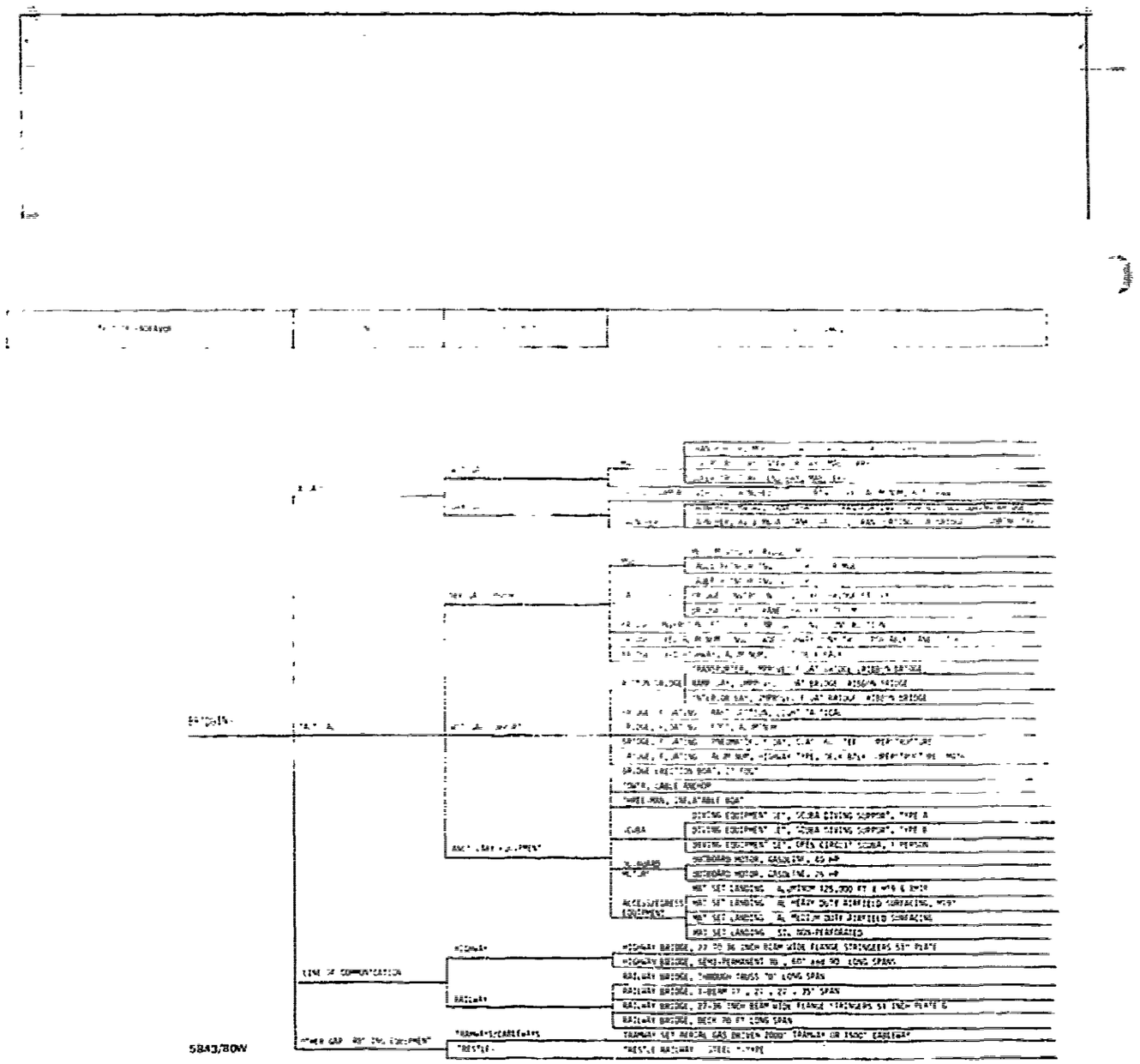


Figure II-1. Baseline Equipment Summary for Bridging

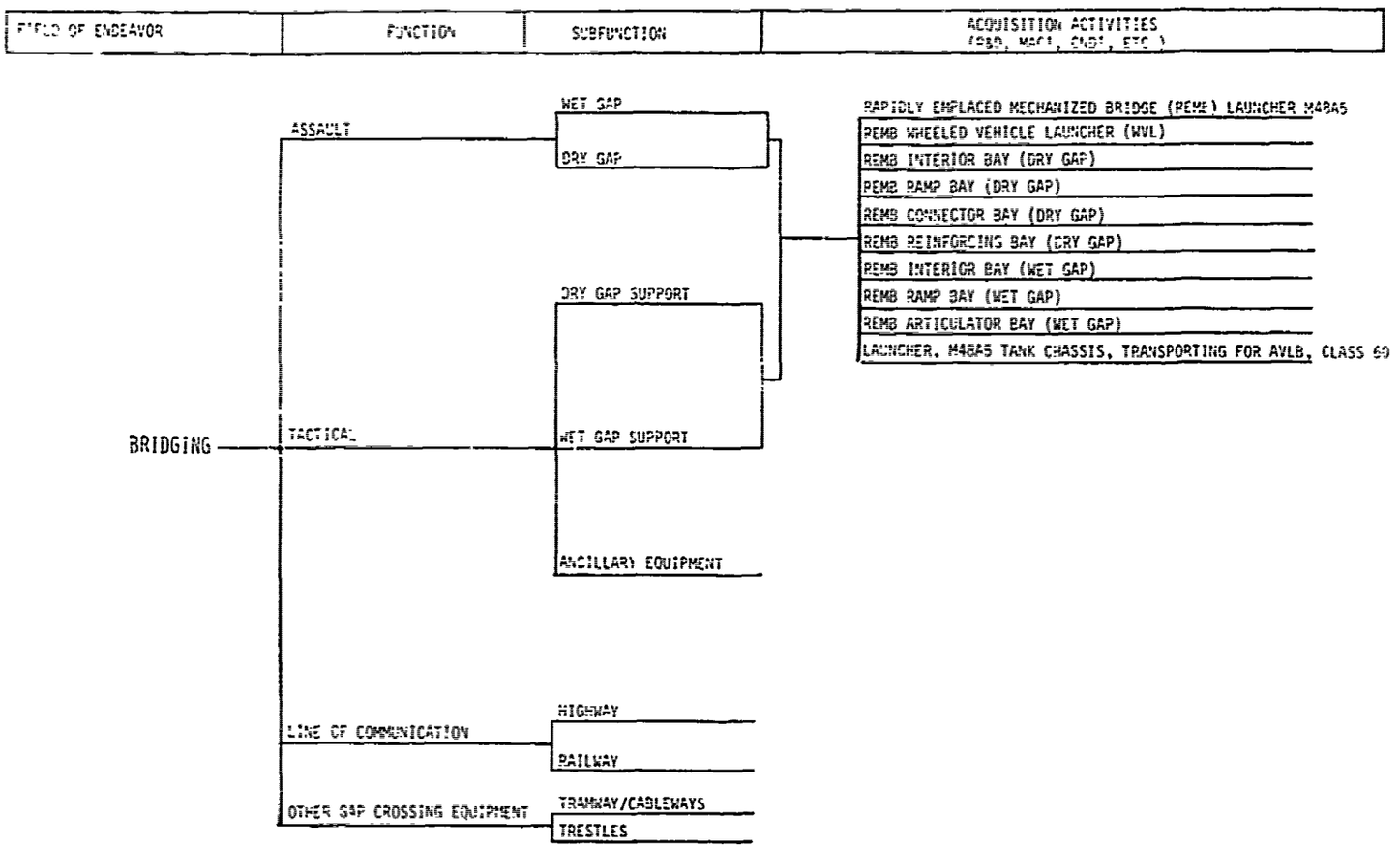


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Figure II-2. Summary of Bridging R&D Materiel Acquisition Activities

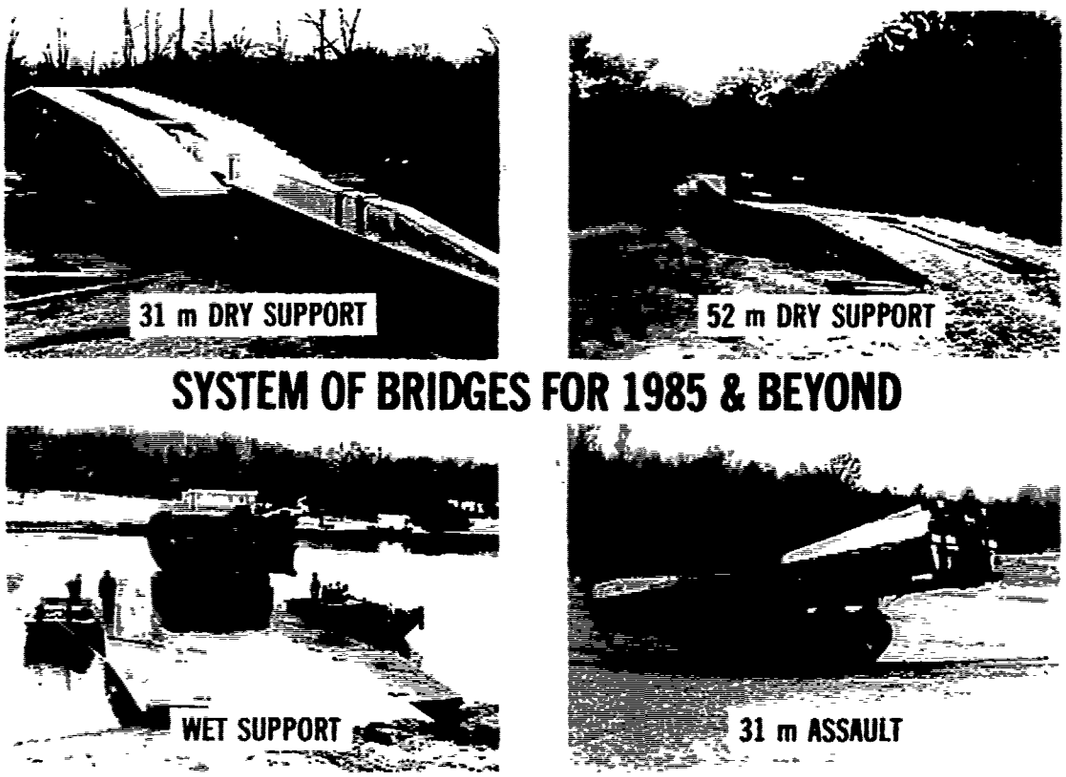

Figure II-3. Bridging Components

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current bridging capability and ongoing acquisition activities versus current needs has revealed the following three major deficiencies.

1. Military Bridging Systems Require Excessive Time and Manpower to Deploy, Emplace, and Recover

Heavy, bulky, and cumbersome current bridging and support equipment is limiting rather than aiding modern battlefield mobility. This is an ironic circumstance since the tactical bridging mission is to enhance the mobility of Army field forces. Current bridging and support equipment is designed to a high strength to weight ratio using high strength, lightweight metals. Improvement in this ratio using metals can only be made at the expense of high-cost quality-controlled fabrication.

2. Military Bridging Systems have Inadequate Reliability, Availability, Maintainability, and Durability Characteristics

There is no acceptable design criteria formally specified for US military bridge design. Design limitations are left to the design engineer and each engineer has different standards. The situation is worse between NATO and other allies. There is no way to measure how much life is left in a bridge. The use of computer models and structural techniques is limited by lack of a uniform failure criteria. Testing to a standard for life is not now defined.

3. US Army has an Inadequate Capability for Getting To (Accessing) and From (Egressing) Bridge Emplacement Locations Under Operational Conditions

The crossing sites for military bridges are often in marginal terrain locations. The track between existing roadways and bridge sites may be through woods, swamps, or through bombed out terrain. The best bridge is useless unless we can access and egress from it quickly and efficiently.

F. BRIDGING SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of MERADCOM S&T efforts have been initiated. These initiatives show significant promise for advancing the capabilities of Military tactical bridging.

Conventional metallic materials can no longer be expected to show significant strength-to-weight improvement required to improve the operational characteristics of military bridges. Fibrous, composite materials are now available which have superior strength and stiffness. These materials show promise of enabling the bridge designer to achieve the desired improved performance in an economical manner. MERADCOM is now investigating the use of high-strength, lightweight composite materials. Investigation

incorporating these materials shows that they not only will reduce the weight and deflection of the bridge but will also increase the service life and clear span capability (33 percent) without modification of the structural configuration. Alternatively, the bridge capability can be improved by raising the class with no increase in the weight of the structure. This program is providing the advanced technology needed for future tactical bridging and is also developing the technology application techniques and expertise base required for the introduction of essential composite materials technology throughout the Army.

In FY79, the Marine and Bridge Laboratory pull-tested the sandwich material which incorporates the high modulus graphite epoxy pultruded strips. Figure II-4 illustrates the new construction technique.

Friction-bolted connections are being investigated as the loadtransfer mechanism to and from these panels. A second version of this bottom chord element is being studied which incorporates continuous winding and eliminates the friction load transfer requirement. A contract for the production of a complete 52-meter composite traversing beam has been awarded. This beam reduces the weight 65 percent over that of the metallic structure. This concept utilizes a series of filament windings which allows orientation of the individual fibers to their most efficient angle. The design incorporates wound-in and bonded-in metallic elements at load-bearing points in conjunction with the graphite epoxy wrap.

The main thrust of the MERADCOM Advanced and Engineering development program is the trilateral effort entitled Bridging-for-the-80's. Improved response time, target-acquisition capability, range, and accuracy of enemy weapons all indicate that, in the post-1985 time frame, concentration of troops will be quickly detected, identified, located, and engaged. It is essential, therefore, that future bridging systems be capable of providing field forces with means of crossing tactically significant wet or dry gaps in considerably less time, with lower manpower requirements, and with minimum exposure of personnel. Also, future bridging systems must have improved survivability, be capable of rapid recovery, dismantling, and dispersion, be easily camouflaged, be capable of operation under all conditions of visibility, and be easily destroyed to prevent capture intact by the enemy.

To meet these rigid requirements, the US has entered into an international cooperative development program with Germany and the United Kingdom. The Bridging for 1985 and Beyond program will feature a family system of common bridge and launching components and transport systems for assault and wet- and dry-gap support bridge roles In

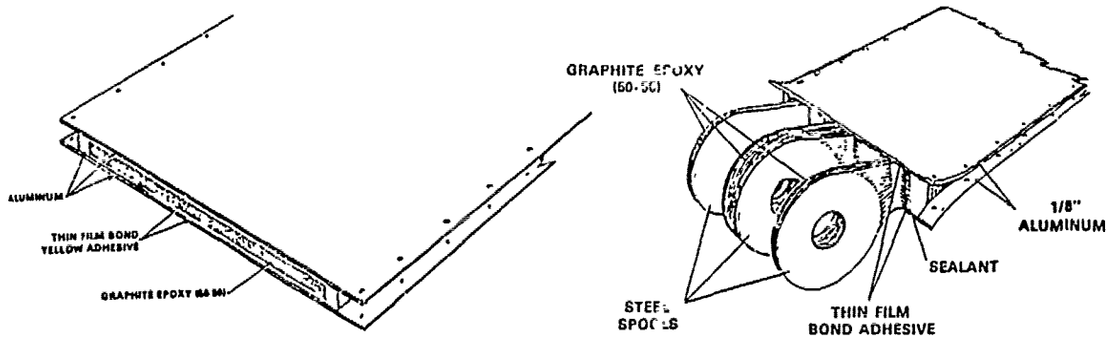

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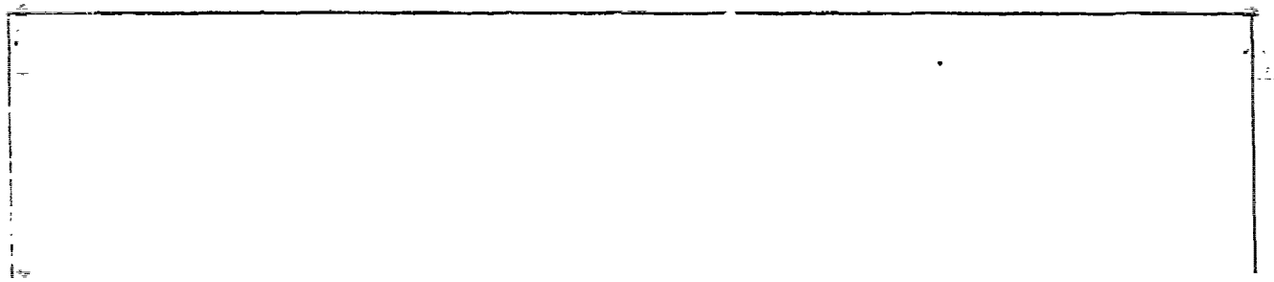
Figure II-4. Graphite Epoxy Sandwich Construction for Bridging



FY79, fabrication of all components to construct a 52-meter, dry-gap support bridge was completed including the reinforcing system needed for all Class 60 spans in excess of 31 meters up to and including 52 meters.

All components to convert the dry-gap support bridge to a wet-gap support bridge were fabricated, conversion of bridge bays and the 10x10 wheeled transporter was made, and rafting and bridging tests were initiated. The primary item of developmental hardware in this program is the Rapidly Emplaced Mechanized Bridge (REMB), a state-of-the-art lightweight aluminum bridge consisting of watertight modular "bays." These bays can be combined to form a Class 60 floating bridge of any required length, or a Class 60, self-erecting bridge, which can span 51 meters.

The use of Kevlar material in the tensile cable reinforcement system is being tested in conjunction with the "Bridging-for-the-80's' system.

The finite-element computer model of the bridge is being continuously updated to accept the unique structural properties of the proposed composite elements.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in Paragraph E. A graphic display illustrating the relationships and schedule is provided at Figure II-5.

a. Lightweight Bridging Materials Technology

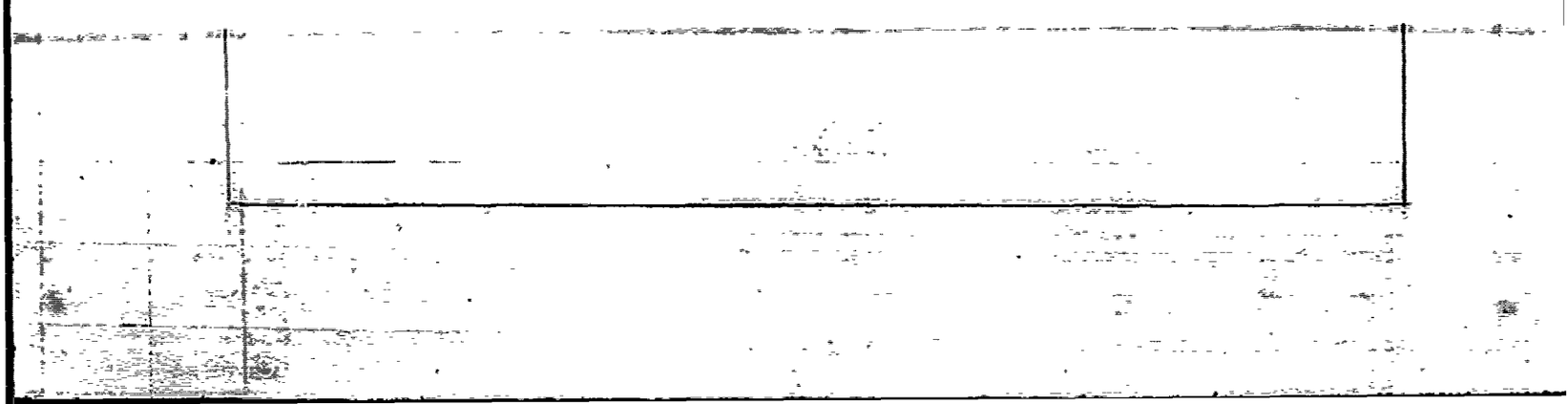
The product of this S&T effort is a body of technical data and physical demonstrations of the value of using modern composite materials in assault and tactical bridge construction. Specific activities in this regard are as follows:

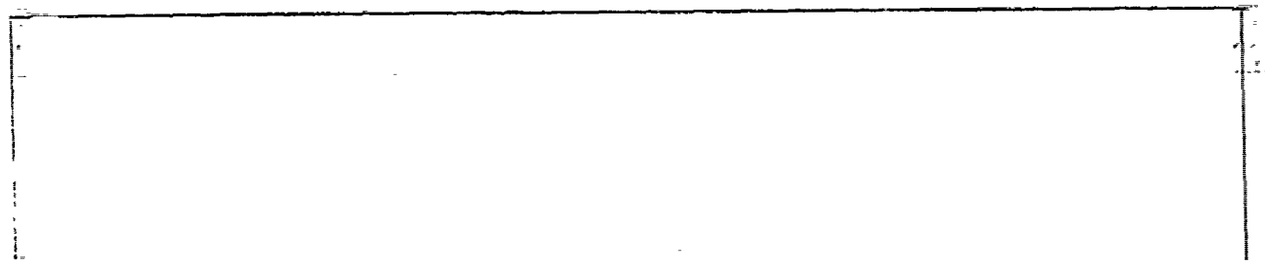
1) Composite Material Tensile Element for Bridge Reinforcement

This technology will drastically reduce the weight of the bridge reinforcement members needed to extend the standard 31m bridge to the required maximum length of 52m. Existing metal bridge reinforcement members each weigh approximately 200 pounds and require a squad of troops to emplace. With the new technology, one man can carry a complete bridge reinforcement member by himself thus significantly decreasing manpower requirements and decreasing assembly and recovery times.

This effort will devise and demonstrate the required "continuously wound member with built-in end connectors" fabrication techniques.

The unique tensile properties of multiple strand fibrous composite, continuously wrapped around built-in eye sockets, can provide tensile elements of fixed,





but any length member for bridge reinforcement. The combination of factors of low stretch, high strength, and low density will provide cable and bar members which are an order of magnitude (10 times) lighter than equivalent members in conventional metal construction.

2) Lightweight Modular Graphite/Epoxy Composite Traversing Beam

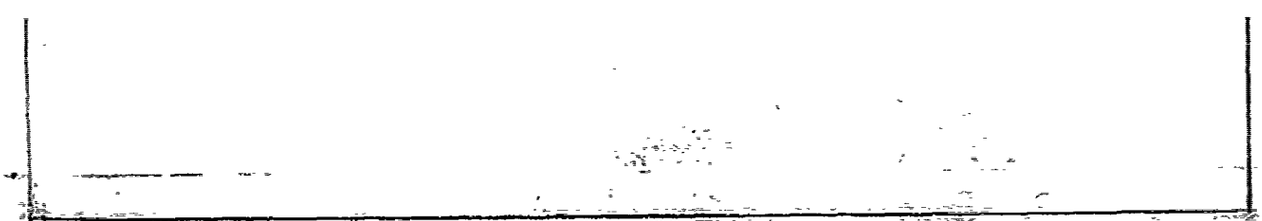
This effort will devise and experimentally demonstrate the required fabrication and engineering techniques required to adapt the available extensive space-age technology to the low-cost requirements of the military bridging application.

This technology will reduce the weight of the existing beam by approximately 60 percent. This reduction substantially increases the mobility of the bridge systems thereby increasing their availability and decreasing the deployment time. The reduced weight also decreases the load on the bridge launcher/transporter and the bridge components thus significantly increasing the durability of the bridge and its deployment system.

The all graphite/epoxy composite traversing beam combines a material and fabrication technique new to bridging. The beam is made by winding epoxy wetted graphite on an inflated mandril The flanges are continuously wound epoxy-graphite over steel spools to provide a chain link element with high bearing pinned connections at the spools. The spacing on the spools can be varied to provide elements of any modular length (ours is 1 meter and 7 meters). The link elements are sandwiched side by side and layed on the previously wound mandril both top and bottom to provide top and bottom flanges of the beam. Honeycomb cores are laid on the sides of the mandril and the complete lay-up is overwound to provide a single unit with all connections built in. This multi-wound element is then cured (literally baked in an oven) to provide a rigid beam module which can replace a current all-metallic beam and weigh 65 percent less. The fabrication method is an assembly line low labor intensive technique which promises to offset high material costs by low man-hour fabrication.

3) Metal Matrix Bridge Components

Metal matrix is a composite material in which the binder material (epoxy in organics) is a metal such as aluminum or magnesium. The objective here is to achieve the high strength/stiffness of fibrous composite (graphite, boron, silicon carbide) with the desirable properties (machining, connection, transverse strength, durability) of metal. The end products will be lightweight, super strong, and durable structural elements which will reduce weight and increase life of bridging equipment.



4) Adhesive Structural Joints

The use of composite bridge components in conjunction with metallic elements has made the joining of these two materials an important part of bridge structural design. The product of this effort will be the specification of the geometric constraints required to maintain the level of physical property necessary to insure efficient load transfer. Adhesives are the major effort here since composites offer very low bearing stress allowable and, therefore, mechanical attachments (rivets and bolts) are of little value. The adhesive joint in composite material is the equivalent of a weld in metallics and insures lightweight, continuity, and the ability of simple module replacement.

5) Modular Bridge Web System

The special feature of composite material exploited here is the fluid plastic consistency of the fabricated part prior to final configuration set. Simply stated, we can mold and shape it without machining or welding.

The method of fabrication is the same for each web module: inflate a flexible mandril (long hollow tube); wind tube with composite (fiberglass is cheaper and lighter than even aluminum); lay on web spacers (built-in stiffeners); wind it again with composite and deflate the mandril slightly (inserting it into the mold shape desired) and reinflate.

The result of this procedure is the same for all bridge configurations being considered. A totally sealed, hollow celled stiff web structure which can be either bolted or bonded (probably both) to the top deck, and also the bottom chord.

The web module is cheap, mass producible, easy to repair, and for extreme damage - expendable. It is 25 percent lighter than the metallic system it replaces.

b. High Durability Bridging System Technology

This product is an integrated system of software, design codes, and instrumentation that will assure the durability of new and existing tactical bridging. Specific activities in support of this product are:

1) Design and Test Code for Military Bridging and Gap Crossing Equipment

Neither US nor NATO military bridges have been designed to a common standard, with the result that commonly used bridge classifications (e.g., Class 60) have no common meaning. Among the more critical aspects of the problem are lack of definition of: (a) the environments (e.g., water velocity) in which the bridge meets its classification and, (b) the number of crossings by rated load

which it can withstand. This lack of a common standard largely results from the lack of adequate test procedures and standards. This effort will develop adequate bridge test criteria and integrate them into a comprehensive universal military bridge design standard. The existence of a universal military bridge design standard will minimize the failure of military bridges, and increase commonality of bridges and components. This will increase interchangeability, interoperability, maintainability, availability, and durability. At the same time, it offers substantial reductions in cost and logistics burden.

The Code will initially be trilateral (US, UK, GE) with the eventual acceptancy by NATO and other friendly forces as an objective.

2) Mathematical Computer Model of Modular Bridge

There is no way for field commanders to determine the effect of a field modification. The strengthening of a damaged section may actually decrease the capability of the overall system. The use of a computer model of the bridge will allow the evaluation of a modification or fix without the need for the laborious and time consuming methods now required. One needs only to plug in the change desired/required and the computer will determine the effect of the change.

The finite element model of a structure as made up of known pieces such as rods, bars, beams, plates, etc., is a relatively new technique for structural analysis. The method has been made possible by the ever increasing storage capacities of modern computers.

The model of the Bridging in the 80's modular bridge makes it possible to substitute basic modules in the bridge (example - change bottom chord to composite sandwich panel) and by simply changing the input for one finite element, determining the effect on the whole bridge.

It is also possible to test the bridge with a new member in it and by inputting its measured characteristics, have the computer characterize its structure.

This technique will give the designer a record and history of every change he makes and its cause/effect on the bridge.

3) Determine a Measureable Fatigue Phenomena and Produce a Device for Its Measure

The relatively short life of a military bridge in comparison to a highway bridge and the high level of stress associated with efficient design has made the effects of low cycle fatigue a controlling characteristic. The fatigue phenomena, although known for many years, is still not thoroughly understood. If a measurable physical characteristic can be found and its change quantified with

respect to the cycle life of the material, then a device could be devised to measure the life and thereby reduce logistic burdens and eliminate fatigue failure. Simple inspection of the device would tell the inspector how many more crossings a bridge element could withstand before replacement was necessary. This is a high risk program and results are not expected until the 1985-1990 time-frame. Success would mean massive reduction in cost of bridge members.

c. Modular Roadway Component Technology

This product is the provision of the technical base elements for the development of lightweight, rapidly deployable, prefabricated, expendable roadway which will allow traffic to connect between the existing road net and the sites at which tactical bridging has been erected. This situation allows an enemy to concentrate his defenses at the few good access bridge sites and to deploy against the small US force that can be moved over these bottleneck approaches.

Military bridges are usually erected at sites more or less removed from the hard surface of the permanent road system. Therefore, traffic to and from a military bridge site normally is forced to travel cross country or over hastily improvised roads to get on and off the bridge. The cross country or hasty road traffic carrying capability

The area between the old road and the new military bridge site has been the most overlooked and weakest link in battlefield mobility. This normally short distance can be anything from swamp to shell cratered terrain.

1) Modular Roadway System Demonstration

This program will provide the basis for lightweight, self-stacking roadway modules which can be automatically deployed from the rear of a moving truck to form a road to and from tactical bridges. The modules will be buoyant in swamp and stiff over craters and ditches. Each module will be simply connected to its adjacent module so that it can be readily emplaced in the field.

2) Modular Roadway System Design Specification

The prime material candidate for this structure is a low density foam casting, continuously wound with epoxy fiberglass.

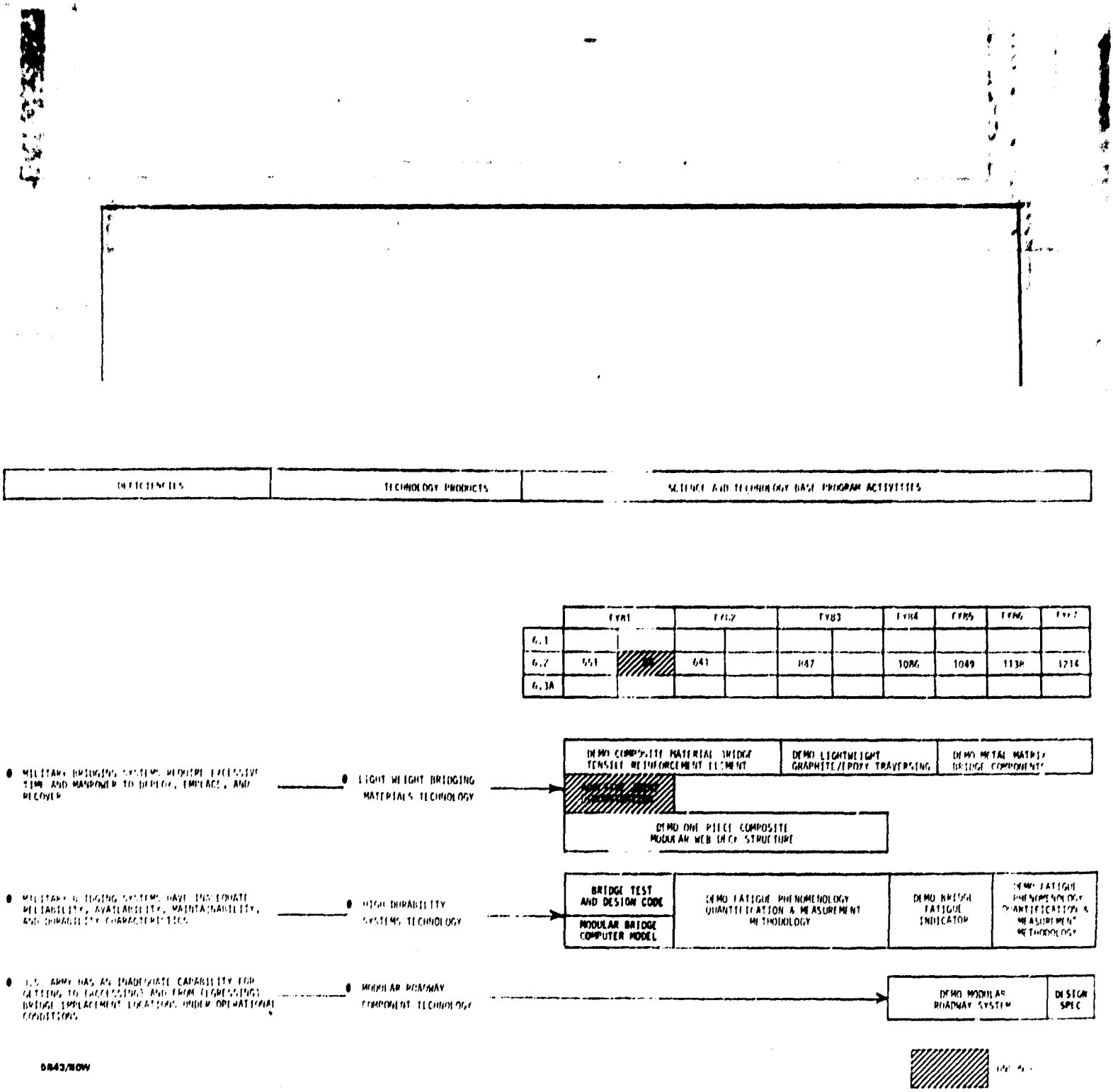
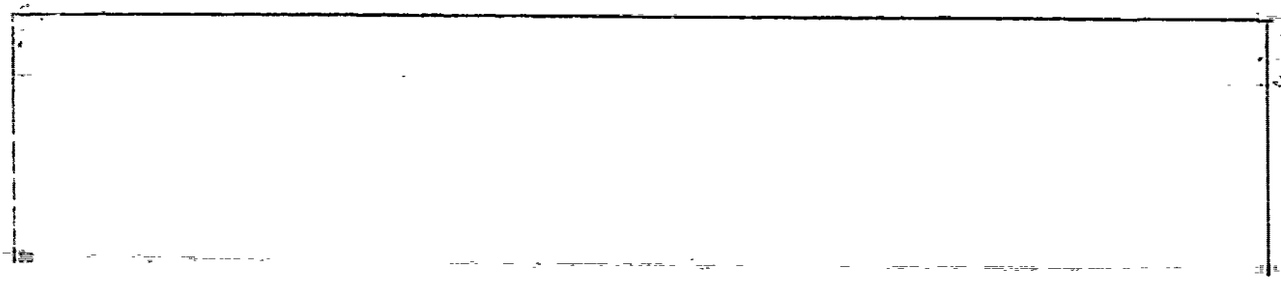
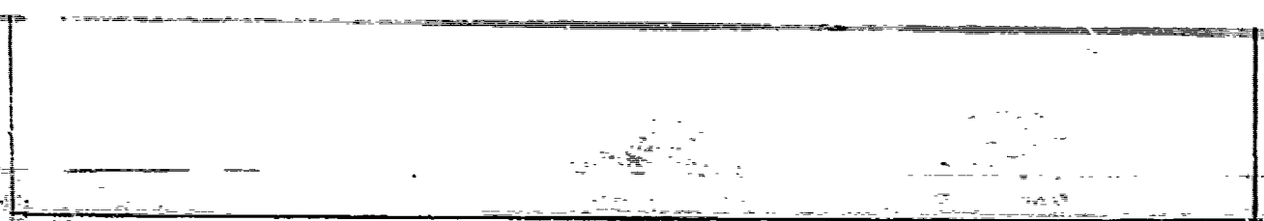


Figure II-5. USAMERADCOM Bridging Science and Technology Base Program Activities



CHAPTER III
COUNTERMINE



CHAPTER III
COUNTERMINE

A. MILITARY SIGNIFICANCE AND NEED

Countermine systems defeat Threat minefields thus enabling US forces to maneuver decisively in order to concentrate, fight and win on the integrated battlefield. US forces must be able to detect minefield barriers early and neutralize them rapidly in order to maximize flexibility for maneuver units and minimize friendly casualties in both personnel and vehicles.

B. FUNCTIONAL CAPABILITY

Countermine can be divided into the following three major functional areas:

1. Mine Detection

This function provides a means of locating minefields prior to an adverse encounter. It involves detection of metallic and non-metallic mines under fluid as well as static battlefield situations. Mine detection should be responsive to unique tactical and minefield situations, and provide commanders with intelligence concerning minefields early enough to permit the selection of tactical options appropriate to the threat. The principal subfunctions of mine detection are detection of the mine proper, the mine laying and environmental disturbance, the mine functioning, and the minefield.

2. Mine Neutralization

The mine neutralization function has the goal of movement, unimpeded by mines. Subfunctions include:

(1) Simulation of the target signature causing the mine to detonate prematurely;
(2) Reduction or masking the target signature, causing the mine to fail to detonate;
(3) Removal of the mines;
(4) Damaging the mine;
(5) Reduction of target damage; and
(6) Minefield marking.

3. Integration of Countermine Systems and Techniques

This function integrates the full range of countermine and counterobstacle technology and techniques. Attention is given not only to the technical performance of countermine hardware but also to the total impact of integrated counterobstacle systems on the overall accomplishment of combat missions. A primary objective of this effort is to define a family of countermine capabilities which will respond more adequately to the whole spectrum of threats, environments, and missions.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to counter mines consists of the existing equipment presented in Figure III-1. Descriptions of each of these ite· are provided in Volume V of the MERADCOM Digest of Existing and Developmental Items of Equipment and Systems. Tne major existing countermine capabilities are summarized below.

1. Mine Detection

Mine detectors currently in the Army inventory are the standard detector of metallic mines (AN/PSS-11), two metallic/nonmetallic mine detectors (AN/PRS-7 and AN/PRS-4) and a truck mounted AN/VRS mine detector set. The three portable mine detectors require 15 minutes to set up and can be operated by a dismounted soldier. The truck mounted (AN/VRS) mine detector detects surface and buried metallic mines from a modified 1/4 ton truck at a rate of 8 mph on paved roads or 1 to 3 mph over rough terrain. Its search path width is approximately 77 inches. When a mine is detected, the vehicle is automatically braked and declutched.

Dog patrols can also be used with some success for mine detection by sensing mine laying activities and environmental disturbances. A trained dog under control of his handler can quarter a 6 to 8 foot path. The dog is trained to stop and sit when a detection is made. The Army has no current program, however, to acquire and train dogs for this purpose.

2. Mine Neutralization

Although rollers have been used in past wars, the current capability to neturalize mines consists of the Demolition Kit (M157), the Rocket Projected Line Charge (M173), the Projected Line Charge (M1E1), the Bangalore Torpedo, the CEV Gun Round (M123A) and the Helicopter Delivered Fuel Air Explosive System (FAESHED). All of the line charges, the M157 Kit, Bangalore Torpedo and CEV Gun Round employ conventional explosives to detonate mines. The FAESHED Mine Neutralizer consists of two standard Navy CBU-55/B weapons mounted on an Army UH-1H helicopter. The CBU-55/B is a fuel-air bomb cluster, free fall munition which employs ignition of an aerosol cloud of ethylene oxide fuel. It is effective against conventional single impulse pressure fuzed mines; however, FAESHED has never been type classified, in part because the helicopter would be extremely vulnerable when delivering the munitions. Other current techniques for mine neutralization include removing the mine, reducing target damage and marking known mines and minefields.

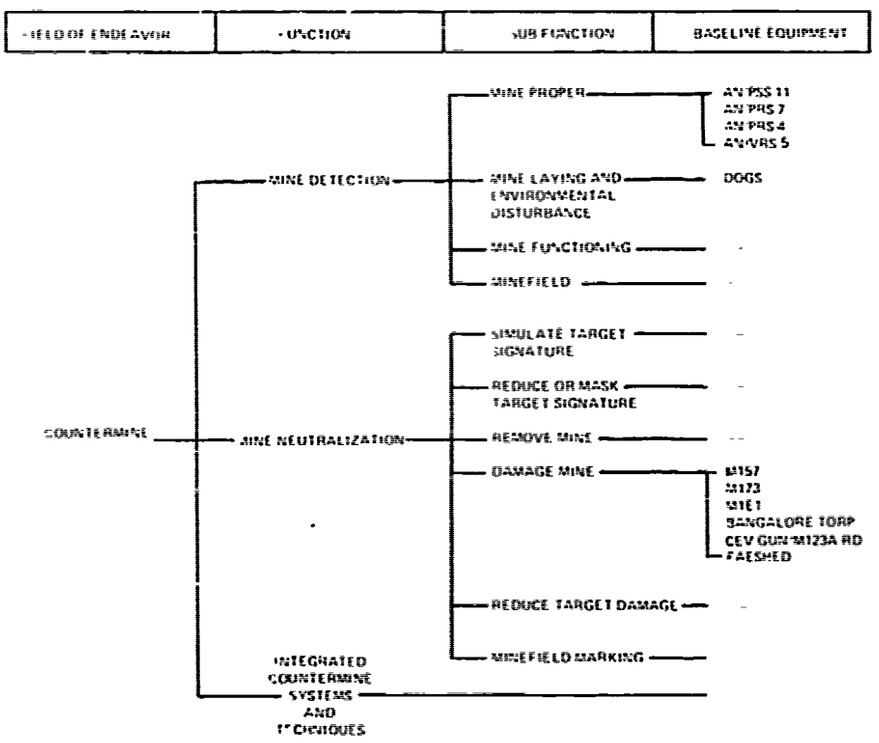


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Figure III-1. Baseline Equipment Summary, Countermine

3. Integrated Countermine Systems and Techniques

Technical data have been collected on the environment, Threat, equipment performance and mission requirements for mid- to high-intensity warfare in Western Europe. Scenarios have been prepared and computerized models developed to examine and compare alternative countermine hardware items and system concepts. The entire effort has been coordinated with the Army's combat developers, the US Navy and Marine Corps, external contractors, and DARCOM supporting elements.

Computerized simulation models have been developed and used to examine the effectiveness of concepts, individual R&D hardware and integrated countermine systems functioning on a realistic combined arms battlefield. The models/simulations range from simple deterministic code to large, complex Monte-Carlo simulations capable of incorporating environment, mobility, and combined arms activities. All are operational on the MERADCOM CDC 6600 computer. Specific examples include the Countermine Minefield Effectiveness Simulation (COMMES) which has been used to simulate various vehicles and neutralization devices such as plows rollers, and split track vehicles traversing various minefields.

D. ACQUISITION ACTIVITIES

Figure III-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs. At present these activities are focused on early intelligence to field commanders concerning minefields, improved mine detection, non-destructive mine neutralization, improved capability to explosively breach minefields, and an integrated mine neutralization/detection capability.

Improved detection of mines will be achieved with the modernization of the AN/PSS-11, application of product improvements to the AN/PRS-7, and development of the Vehicle Mounted Road Mine Detection System (AN/VRS-5). The AN/VRS-5 is intended to meet the destructive threat which mines represent to both utility and tracked vehicles. It is designed to detect antitank and antivehicle mines buried up to 12 inches deep in lines of communication, secondary roadways, and sparsely vegetated terrain. See Figure III-3.

Mine neutralization improvements include: Development of the Vehicle Magnetic Signature Duplicator (VEMASID) to neturalize magnetically fuzed antitank mines; Development of a track-width roller for the M60 tank to neutralize pulse pressure fuzed mines and tilt rod mines; Development of the trailer mounted Mine Clearing Line Charge (MICLIC) which employs a rocket propelled line charge to breach a path

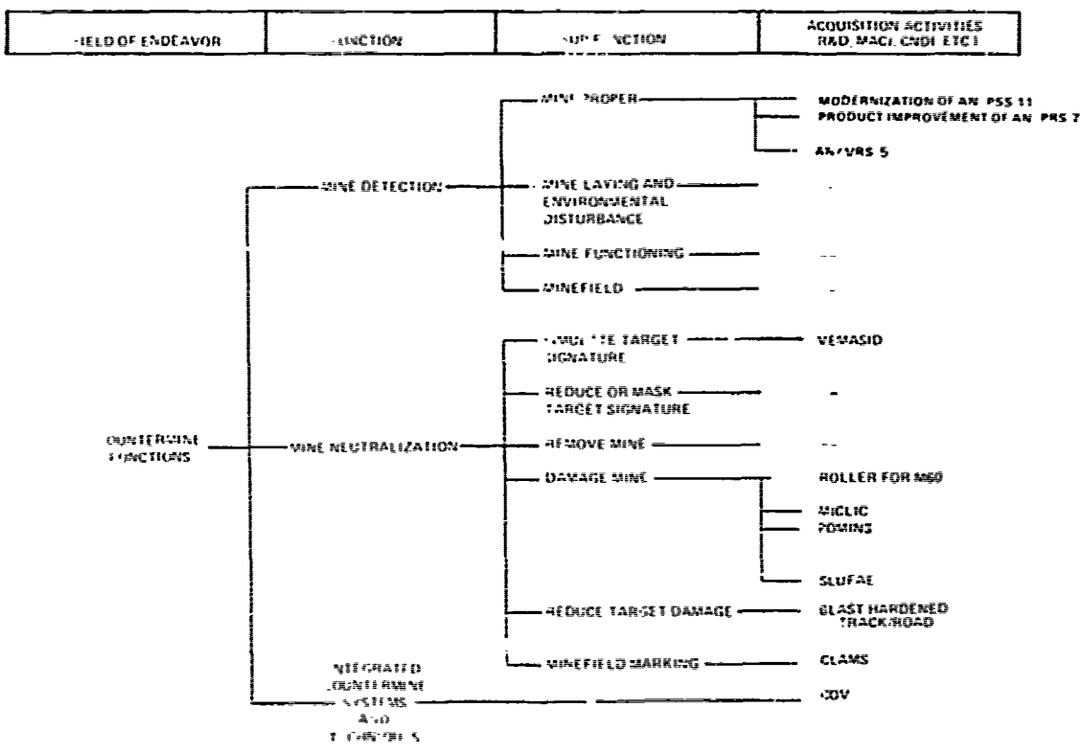


Figure III-2. Summary of Countermine R&D Material Acquisition Activities

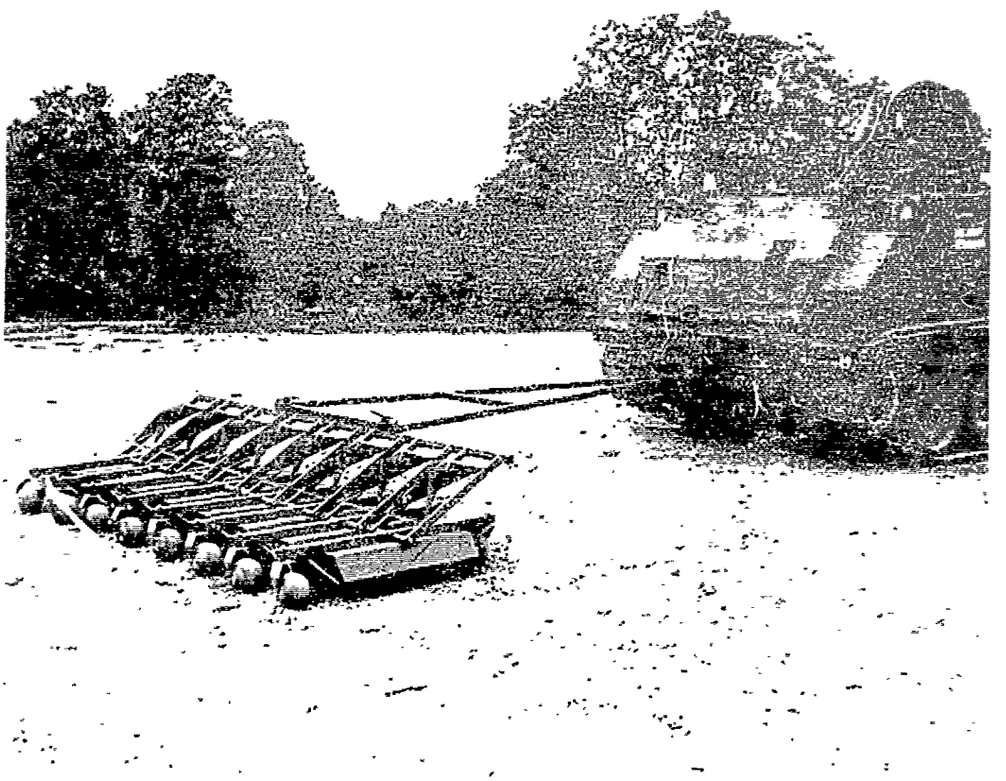


Figure III-3. Vehicle Mounted Road Mine Detection System (AN/VRS-5)

through antitank minefields, Development of the Portable Mine Neutralization System (POMINS) to provide a manportable capability for rapidly creating a safe lane or foot path through a minefield and associated wire obstacles, Development of the Cleared Lane Marking System (CLAMS) to provide a visual indication of paths cleared through minefields for subsequent traffic, and, blast hardening of tracks to reduce damage from mines. The Surface Launched Unit Fuel Air Explosive (SLUFAE) system was recently type classified in December 1980 and now awaits procurement action. SLUFAE consists of a 30-tube launcher which fires 85 lb rounds containing propylene oxide fuel. Upon detonation, a salvo is capable of creating a 240 meter breach in a minefield from a standoff range of about 1000 m. Hand Emplaced Minefield Marking Set (HEMMS) has recently been standardized to provide a rapid temporary marking capability.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current countermine capabilities with current needs indicates there are three major deficiencies:

1. Inability to Adequately Detect Minefields Before Adverse Encounters

No technology is presently known which provides a useful capability for detecting minefields at long range, in real time, and in a manner responsive to the operational needs of the user. The user needs to detect minefields sufficiently far in advance to enable him to maneuver around them or to have time to deploy adequate minefield breaching equipment so that the Threat minefield does not impede the intended maneuver. Several technologies are available which detect selected classes of minefields under limited environmental conditions. None of these technologies has demonstrated potentially acceptable response time, platform survivability cost, complexity or logistic burden.

2. Lack of Adequate Standoff Minefield Breaching Capability

There presently exists no long standoff minefield breaching capability in the US Army. Present countermine equipment requires deployment by troops under direct fire at the FEBA or within 1000 meters in the case of SLUFAE. This significantly decreases the probability of success because the deployment equipment is quite distinctive and makes an inviting target for threat forces. The equipment must be operated at slow speeds and if destroyed cannot be readily replaced due to its low density in the inventory.

3. Inability to Adequately Detect/Neutralize All Threat Mines at an Adequate Rate With an Acceptable Operation/Logistic Burden

Present mine detection technology cannot provide adequate area search rates even under ideal conditions.

When searching for non-metallic mines an operator will be subjected to excessive system false alarm rates. In addition, metallic mine detectors cannot distinguish between metallic mines and metallic debris, such as shell fragments. Existing mine neutralizers are slow and vulnerable, and are unacceptably burdensome to the user. Explosive mine neutralizers impose large logistic burdens and existing non-explosive mine neutralizers are excessively cumbersome and awkward to use.

F. COUNTERMINE SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of Science and Technology (S&T) efforts have been initiated. These initiatives show significant promise for advancing the US Army capability to counter mines. This improved capability would permit Army combat units to operate and maintain momentum in the presence of mines without undue penalty in losses, time delay or effort expended.

The technical goal of the Countermine Program is to explore and reveal new possibilities and principles in detection and neutralization technology. The long range goal is the development of a Countermine System for the detection and neutralization of explosive materials irrespective of case material, shape, fuzing, emplacement means or location. In order to accomplish these goals the MERADCOM Science and Technology Base is directed toward four major thrusts, standoff minefield detection, defeat of advanced design mines, a counter obstacle vehicle, and countermine operations in MOUT(Military Operations in Urbarized Terrain).

In order to achieve a standoff minefield detection capability, MERADCOM is concentrating on the use of information from existing sensors to provide insight into development of more advanced, effective systems. The program will identify sensors which have the potential to provide minefield information and then will develop methods and techniques for providing the required information to the user in a timely manner. The continuous evolution of microwave components, measurement systems, microprocessor technology, and the theory of target scattering makes these technologies most likely for the development of new portable, vehicular, and airborne mine detectors. Electromagnetics provides the only approach for rapidly interrogating large areas in short times and will usually be the initial detection mechanism of choice. Residual clutter or false-alarm problems may necessitate the use of other technologies for confirmation, or alone in areas hostile to electromagnetic detection. Thus, in MOUT operations, the detection of individual mines may

require devices or close-in systems with high specificity for TNT or other main charge explosives.

Recent trends in the concepts of mine warfare have been toward use of surface minefields as effective flank protection during offensive maneuvers as well as a quick and effective way to achieve disengagement during tactical withdrawals. Perhaps the greatest potential change in mine warfare of this century is the concept of remotely deliverable, complex fuzed mines which can be used as both an offensive and defensive weapon. An attacker may use scatterable mines to isolate an area of the battlefield from reinforcement and enable him to achieve a breakthrough before the defender can react. A defender may use scatterable mines to prevent the attacker from rapidly concentrating for a breakthrough and buy the time needed to shift and dig in his defensive forces.

These new concepts and tactics raise important questions concerning all countermine equipment, its design, who will employ it, and where and when it will be employed. The Training and Doctrine Command is addressing these questions in the development of a "Concept Paper on Countermine" which must form the basis for future research emphasis in this difficult field.

Because the Threat is varied and complex, no single mine neutralization device is likely to satisfy all possible situations in all possible scenarios. A countermine system (or systems) is needed which has the flexibility to meet the commander's needs in a battlefield environment. The system will consist of several devices (detectors, rollers, line charges, marking signs) integrated through training and doctrine to form an accepted part of tactical plans and operations. The shortcomings of any single mine neutralizer device can be overcome to some extent by the good features of another if they are used in tandem as a system.

In the longer term, total systems will improve through the development of better components or the replacement of one component by another. Thus, a better line charge will replace the current standard M173. The new track-width mine roller will probably undergo changes as a result of field use, become lighter, and evolve as more of a mine detector than a mine neutralizer. A light weight track-width plow or scarifier which can be lowered from the carry to the dig position at the edge of a detected field offers promise as a replacement neutralizer. A requirement for standoff breaching capability is important. The SLUFAE system projected and detonated from 1000 meters to the rear is a step in the right direction and will be added to a total countermine system. An improved system is needed, however, which will be more effective against all types of

mines and fuze combinations and which can be employed from a safer standoff distance.

Another approach consists of multiple capability systems. This approach would incorporate many or all concepts for neutralizing mines. It would probably have various target signature simulation and/or modification features (roller, magnetic coil) to attack and actuate mine fuzes. It could also have features to remove or attack the mine proper (scarifier, explosive projectiles). It would probably need and adopt the latest advances in suspension hardening and protective armor. Finally, it could well incorporate a minefield marking capability to designate cleared lanes for following combat assault vehicles. A concept for a courter obstacle vehicle (COV) with such multiple capabilities is under study.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed in paragraph E, above. A graphic display illustrating the relationships and schedule is provided at Figure III-4.

a. Airborne Sensors

The product of this S&T effort is the Airborne Minefield Detection System (AMIDS), which is an experimental model of a remotely piloted vehicle (RPV) and reconnaissance sensor system for minefield detection. This technique should be of particular value in detecting hasty minefields and scatterable mines which have been recently introduced into the inventories of several of the worlds leading military forces. This form of detection system is particularly suited to battlefield conditions where conventional reconnaissance assets are limited and response time is critical. Specific features of this system involve:

1) Sensor Feasibility Demonstration

The experimental AMIDS system consists of an electrooptical sensor compatible with planned RPV assets and with that portion of ground station equipment necessary to augment or replace planned equipment as necessary to demonstrate feasibility and gain experience with an operational AMIDS.

2) Specification for Design of Product

This system is offered as the best solution to the requirement for a fast response, remote minefield detection system for use in the fluid battlefield situations expected in the active defense of Europe. It will enhance mobility of combat forces on the battlefield by providing timely information on obstacles. Another utility of the system is the degradation of hostile tactical weapons systems and provision of an accurate responsive means of

retrieving tactical information and intelligence. Finally, the product will allow experimental evaluation of the technical and operational factors influencing the utility of such systems.

3) Demonstration of Prototype

There will be a demonstration of the AMIDS to determine the ground station equipment necessary to augment or replace planned equipment. Other AMIDS research efforts will predict and measure target responses to different remote air sensing techniques and new concepts evolving from the industrial community which may have application to remote mine sensors.

b. Mission Planners and Imagery Interpreters Guides to Minefield Detection

The product of this research effort is guidance and software which will enhance the use of existing reconnaissance assets in a minefield detection role. The mission planners guide will detail operational and technical factors which will increase the likelihood of obtaining imagery suitable for minefield detection, consistent with those assets principal mission. The imagery interpreters guide will instruct and assist personnel in identifying minefields and the conditions under which an absence of minefields may be confidently asserted. Specific activities are as follows:

1) Development of Data and Draft Handbook

The handbook will be drafted during FY81-82. The data and experience to be provided in this handbook are directly applicable, and in part necessary, to the development of AMIDS. The handbook's utilization will enhance the ability of combat forces to prevent the isolation on the battlefield.

2) Operational Demonstration

During FY83-84 the draft handbook will be evaluated in various operational environments. It should provide an attractive solution to the remote minefield detection requirements from the standpoint of economy. Operational limitations arising from asset distribution and response time constraints restrict this product's applicability to rather static well developed battlefield situations. However, potential payoff is high in those cases where applicable.

3) Imagery Interpretor's Handbook

The handbook will be published in FY85. It will instruct and assist personnel in identifying minefields and the conditions under which an absence of minefields may be confidently asserted.

c. Electromagnetic Minefield Sensing

The product of this S&T effort will be design specifications for optimal electromagnetic minefield sensors or radars. Specific activities are:

1) Demonstration of Mines Electromagnetic/ Magnetic Scattering Model

A math model for calculating the electromagnetic scattering of buried and surface mines as a function of frequency, polarization, and soil properties, is to be developed through a joint ARO/MERADCOM program. The model will be verified through experimental tests on select targets and then exercised to establish a permanent digital data base or library of target responses. Background responses of critical areas of the world will be measured, digitized, and stored for evaluation of clutter levels.

2) Development of Minefield Model

Another model will then be developed to calculate the effective scattering expected from a minefield array based on single target behavior as stored in the data base. Both monostatic and bistatic cases can be analyzed and compared for utility. The preliminary thrust will be to identify unique minefield responses which may exist at foliage penetration wavelengths on the order of intermine spacing

3) Sensor/Processing Specifications

The models and data library produced under this program will permit realistic evaluation of alternative designs and, when tested against background data, will indicate potential utility in the real world. The final product will be design specifications for candidate remote minefield electromagnetic sensors or radars which could be prototyped in a follow-up program.

d. CANETIP

This basic research will ultimately lead to the improvement of CANETIP mine neutralization systems being developed to give wide area clearance to all types of mines. Specific characteristics of this program are:

1) Demonstration of Feasibility

A basic research program will be conducted to determine the feasibility of using binary systems to enhance CANETIP performance. Certain materials that are nominally compatible can be detonated under certain conditions of pressure and temperature. Such binary systems potentially have detonation pressures and temperatures far in excess of current high explosives. This basic research will ultimately lead to the improvement of a CANETIP mine neutralization system being developed to give wide area clearance of all types of mines.

2) Specification of Design

A family of pressure/impulse mine structure response curves is being developed theoretically and experimentally to define the response of a wide variety of mine-types to over-pressures and impulses. Finite element codes are being used to predict mine structure response. These predictions will be correlated with field experiments in which mines are subjected to a CANETIP system.

This approach will result in the definition of an explosive mine neutralization system that would be effective against all types of land mines irrespective of fuzing type. As an interim technical product, this basic research will ultimately lead to the fielding of a CANETIP mine neutralization system that can be deployed at large standoff distances.

3) Demonstration of Prototype

Prototype countermine weapons will be fabricated and field tested against representative minefields to demonstrate the feasibility and performance potential of new countermine weapons suitable for advanced system development.

The additional funding increment in FY83 would permit the completion of field testing in FY83. Present core program funds restrict completion of this test until FY84.

e. Reactive Dart

This research will lead to the capability to use energetic penetrators to directly attack the main explosive charge in land mines by the end of FY86. The program includes the following.

1) Feasibility Demonstration

High energy penetrators or darts employing pyrophoric materials will be fired into explosives used as the main explosive charge in land mines. The total energy release of selected pyrophoric materials will be measured for a range of penetrator velocities and penetrator sizes. These data will be used to determine penetrator parameters necessary to initiate burning or detonation in materials representative of main charge explosives.

2) Design Specifications

Upon determination that the concept is feasible, a system will be defined in which large munitions are projected over minefields from a standoff distance. The munitions will explosively fragment, producing a shower of high energy penetrators over mined areas. From the results of this effort, design specification will be developed.

3) Prototype Demonstration

During FY85-86 a prototype demonstration of the Reactive Dart system will be accomplished. This system will give a long standoff capability to indirect fire

weapons. It will be capable of attacking all types of mines irrespective of fuzing.

f. Standoff Line Charge

Advanced delivery techniques are being developed at MERADCOM that will substantially increase the range of a mine clearing line charge configuration. These explosive techniques will also substantially increase the width of the cleared lane and extend the effectiveness of the line charge to include damage to all types of mines.

Current line charges require the system be deployed very close to the mined area. For assault breach conditions, troops are exposed to direct and indirect fire weapons while deploying large amounts of explosive. The improved line charge is to be remotely delivered using a surface-to-surface missile and will provide a standoff countermine capability. This S&T Program will be accomplished as follows:

1) Demonstration of the Base Extraction Rocket

During FY81-82 a feasibility demonstration of an improved Base Extraction Rocket principle will be accomplished. Funding as an increment in FY81-82 will permit the timely determination of feasibility of the Standoff Line Charge in FY83.

2) Ballistics and Fuzing Demonstration

Upon completion of the Base Extraction Rocket demonstration, the ballistic characteristics and improved fuzing concept will be demonstrated. This demonstration will be completed in FY84.

3) Demonstration of the Delivery Rocket

The Rocket Delivery concept feasibility demonstration will begin in FY84.

4) Design Specifications and CANETIP Line Charge Demonstration

The Standoff Line Charge system design specifications will be developed in FY85. Present core program plans would develop the improved line charge by the end of FY87.

g. M-1 Integrated Countermine System

This S&T effort seeks to demonstrate the feasibility and potential effectiveness of an integrated countermine system mounted on the M-1 tank. The increased power available from the turbine power plant in the M-1, compared with the M60 series tank, offers promise of smaller, more acceptable degradation in the mobility and maneuverability of the prime mover when mine neutralizer rollers or plows are attached. Thus, the M-1 tank with roller or plow could relatively quickly make an assault breach in an enemy minefield. Other components of an integrated countermine system built around the M-1 tank might

include a lane proofing explosive line charge system and a clear lane marking system (CLAMS). These latter systems would enable following assault tanks or infantry fighting vehicles to use previously breached lanes with greater impunity.

In general, the roller and plow devices to be considered have been developed in previous MERADCOM programs or are available through various foreign cooperative efforts. Minimal technological effort should be required to mount them on the M-1 tank for system evaluation. Initially, the track-width mine roller and also the track-width mine plow will be evaluated. Later an inter-track scarifier will be added to produce a full-width cleared trace. A magnetized roller will also be tested at a later date.

Explosive proofing will be investigated as part of the Counter Obstacle Vehicle effort. It may be incorporated into the M-1 countermine system at an appropriate time.

The cleared lane marking system (CLAMS) will be a simple rapidly deployable system to be mounted on the M-1 tank. It will clearly mark the breached path for other vehicles conducting the assault breach through the minefield. The system will be operated (i.e., started and stopped) from within the tank to produce a 250 meter marked path that will be visible under all weather conditions, day or night.

The current method employed by the US Army to mark the cleared lane for hasty minefield breaching requires two dismounted soldiers to string tracing (engineer) tape along the center of the breached lane and secure it to the ground with wire staples. This method is time consuming and exposes the marking team to direct and indirect fire enemy weapons. The deployment of CLAMS will reduce casualties to both soldiers and vehicles because it will be rapidly deployable from within the combat tank and more visible under adverse weather and night conditions.

The M-1 S&T effort consists of the following:

1) Prototype Demonstration with the Roller/Plows

Parallel with the prototype demonstration of the track-width tank mounted roller and plows, the CLAMS prototype will be developed and incorporated as an integral part of the M-1 system during FY81.

2) CEP Testing

The feasibility of the M-1 integrated countermine concept will be evaluated during FY82 in a more comprehensive series of field tests.

3) Demonstration with the Intertrack Scarifier

The M-1 system with the tank-mounted intertrack scarifier will be demonstrated in FY83.

4) Demonstration with the Magnetic Roller

During FY84 the M-1 countermine system will be demonstrated with the tank mounted magnetic roller.

h. Counter Obstacle Vehicle

This program conducts a prototype demonstration by FY84 of a dedicated countermine and counterbarrier vehicle for elimination of man-made obstacles. When deployed it will increase the mobility of maneuver forces confronted with battlefield obstacles.

The Counter Obstacle Vehicle will feature countermine mechanical equipment such as full width mine clearing plow, mine clearing roller, etc., capable of neutralizing all land mines regardless of burial depth and type of fuzing. Also the necessary mechanical devices to neutralize man-made obstacles erected in mined areas located in the path of maneuver forces will be developed.

The Counter Obstacle Vehicle is necessary to insure continuous mobility of our armored forces through minefields and to eliminate/reduce the enemy fortified positions. Since land mines are used extensively by the Warsaw Pact Forces in both offensive and defensive operations, the Counter Obstacle Vehicle will need to clear land mines from enemy positions under all battlefield conditions. It will proceed with advancing maneuver forces to clear all obstacles and barriers and, in addition, will be capable of erecting defensive positions as dictated by the mission objective. It will also be capable of stand-off mine neutralization through the use of explosive line charges which could be carried and/or towed. The Counter Obstacle Vehicle S&T program will be conducted as follows:

1) Explosive Proofing

During FY81 the feasibility of explosive proofing breached lanes of unexploded/unneutralized mines using a line charge dragged behind the vehicle will be demonstrated.

2) Blast Hardening

In FY83 the feasibility of developing the hardened suspension system will be demonstrated. Hardened tracks and road wheels will be integrated into the design of the Counter Obstacle Vehicle.

3) Design Specifications

The basic design specifications for the Counter Obstacle Vehicle will be developed during FY81-82.

4) Prototype Demonstration

The Counter Obstacle Vehicle prototype demonstration will be accomplished during FY83-84.

i. Multi-Purpose Detector System

This program will explore new concepts and demonstrate a detection capability in a variety of environments to include MOUT and the Middle East. Present and

anticipated detection technology which depends on the bulk physical, thermal, and electrical characteristics of land mines will be severely false alarm limited in urban terrain or in any para-military operation.

New concepts are required to facilitate specific, sensitive detection of mines and booby traps expected in MOUT and Middle East Scenarios. Research would commence with an examination of the state-of-the-art in nuclear, chemical, and biologic sensing of bulk explosives and explosive traces.

The desired product would be new portable and vehicular systems capable of detecting mines, booby traps, and demolition devices concealed in urban areas, in tunnels, or on bridges. Major scientific advances are required in sensitivity and search rate of known techniques produce a useful capability with a real time search rate. Civilian related research into similar problem areas will be the primary source of concepts for this application. The program will consist of the following.

1) Explosive Biosensor Feasibility Demonstration and Increase Specificity of Biosensors

This FY81-83 effort will examine and demonstrate the feasibility of applying certain biological sensing techniques to explosives detection. It will evaluate the potential merits of the extremely sensitive, highly specific techniques of immunoassay and enzyme immunoassay against the explosive TNT. The application of artificial membranes to practical sensing cells using the immunotechniques will be investigated and methods for quantifying the sensitivity and specificity of resultant devices will be examined.

The technological risk is high since the effort involves state-of-the-art research of a highly innovative nature. The merit of employing systems which seek trace effluents from explosive devices is indefinite since there has been no successful qualification and quantification of these effluents to date. Should the concept prove to have merit, the payoff is excellent. This is because the highly specific nature of the technique should allow for a very low false response probability, thus allowing operations in MOUT environments where few other systems are expected to perform. The STO requirement for rapid, highly flexible detection of booby-traps and occulted explosive would be met in part by such a system.

2) Demonstration of Man Portable EM Scatter

This FY 84-87 effort will demonstrate that a new man-portable system can be developed capable of detecting mines, booby-traps, and demolition devices concealed in urban areas, in tunnels, or on bridges.

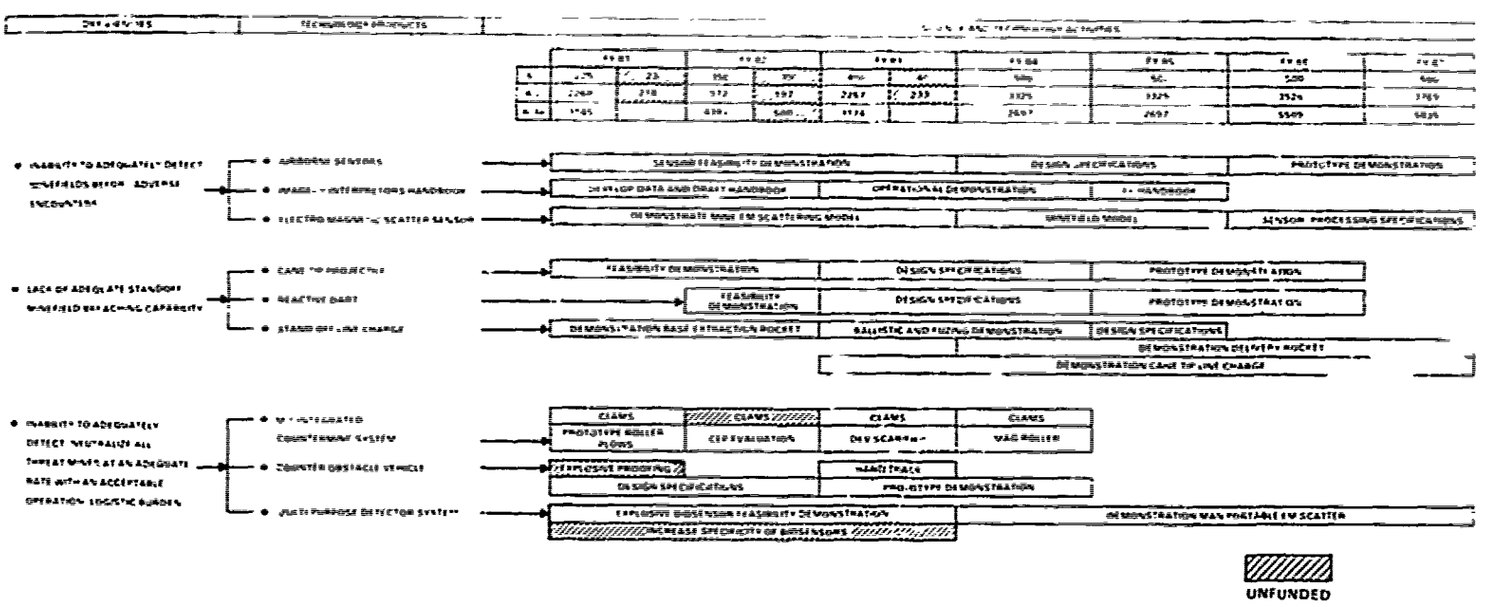


Figure III-4. USAMERADCOM Countermine Science and Technology Base Program Activities

CHAPTER IV
CONSTRUCTION EQUIPMENT

CHAPTER IV
CONSTRUCTION EQUIPMENT

A. MILITARY SIGNIFICANCE AND NEED

Construction equipment enhances ground mobility and provides the counter mobility facilities and survivability construction which enable the US Army to concentrate, fight and win on the integrated battlefield through a wide range of mission tasks.

B. FUNCTIONAL CHARACTERISTICS

Military construction equipment can be divided into the following three major functional areas:

1. Earthmoving

This function involves the clearing of wooded and obstructed areas, the excavating and loading of earth and other materials, the grading and spreading of soil and construction materials, the stockpiling of materials, and the compacting of soil and loose materials subsequent to soil disturbance prior to road building or structure emplacement.

2. Construction and Erection

This function encompasses erecting and craning equipment such as fixed and mobile cranes, pile drivers and booms; snow removal equipment; and fluid power (hydraulic) accessories and components.

3. Materials Movers and Processors

This function includes equipment for production, delivery and placement of bituminous materials; production, delivery and placement of concrete materials; production, storage and delivery of aggregate materials; and air compressors for equipment operation.

C. CURRENT CAPABILITY

A small representative sample of the US Army's near term capability to meet its construction requirements is shown as baseline equipment in Figure IV-1. Descriptions of each of these items are presented in Volume XII of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing construction capabilities are summarized in the following paragraphs.

The Army possesses extremely broad capabilities for earthmoving in the form of numerous items of tractors, dozers, backhoes, trenches, graders, scrapers, rollers, compactors, and other miscellaneous items for use in combat and noncombat environments. Many items of equipment are air-transportable and in some cases are air-droppable by parachute for forward area delivery. Equipment is frequently multi-purpose in that chassis design permits the

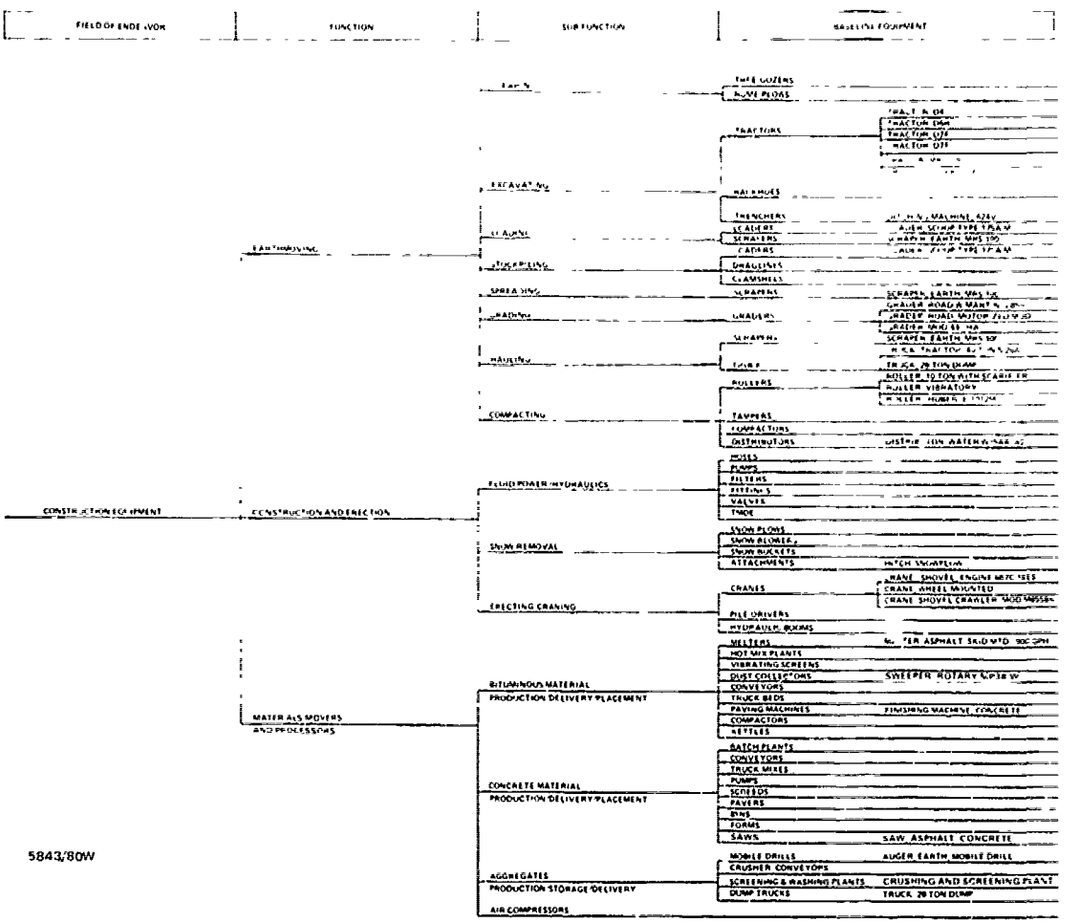


Figure IV-1. Baseline Equipment Summary, Construction Equipment

attachment of special purpose accessories contributing to a high degree of flexibility in operation. Virtually all major pieces of equipment are diesel engine powered thereby simplifying fuel logistics support requirements. Due to the nature of the function, most equipment currently in use is MACI equipment.

One item entering the Army inventory of earthmoving construction equipment as a result of recent MERADCOM development is a 6,000 gallon water distributor which is trailer mounted. The item produces a fan type spray pattern covering widths up to 70 feet for supplying the water required for the compaction of soils. Secondary uses include dust control and fire fighting.

Two other items of equipment entering service are:

1. Hydraulic System Test and Repair Unit (HSTRU), Trailer Mounted

With full deployment of the HSTRU, the online availability of mobile construction equipment will be significantly improved through the ability to analyze and diagnose hydraulic system malfunctions, to make up hose and tube assemblies, to provide for contaminant control following repairs and to provide emergency fluid power on-site.

2. Container Handling Cranes

140 ton and 250 ton container handling cranes are used for the movement and storage of 40 foot standard containers in selected locations.

D. ACQUISITION ACTIVITIES

Figure IV-2 identifies current MERADCOM R&D materiel acquisition activities generated from 6.3, 6.4, MACI and CNDI programs. At present these are focused on the M9 Armored Combat Earthmover (ACE) Vehicle to provide an armored, amphibious, and multipurpose combat engineer earthmover having the essential capabilities of bulldozing, rough grading, excavation, hauling and winching. The ACE will be air transportable and will provide the combat engineer with high speed equipment having mobility equivalent to that of the supported maneuver units. See Figure IV-3.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current construction capability and ongoing acquisition activities versus current needs has revealed a major deficiency.

- Specialized military construction equipment does not exist and available commercial technology cannot execute earthmoving and construction operations at the performance rate required for military operations over the full range of battlefield environments.

New and/or improved construction equipment capabilities are required for timely execution of military unique

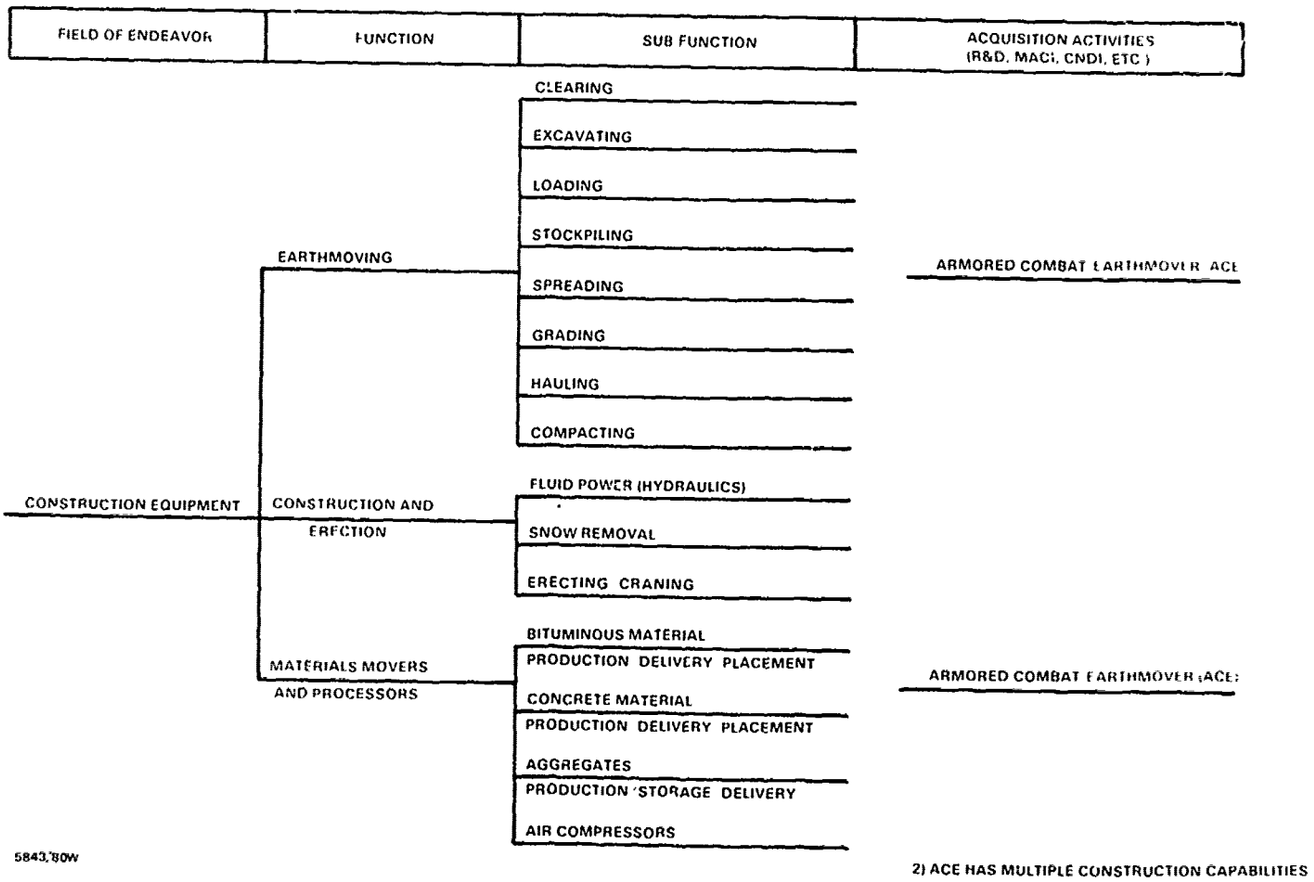


Figure IV-2. Summary of Construction Equipment R&D Materiel Acquisition Activities

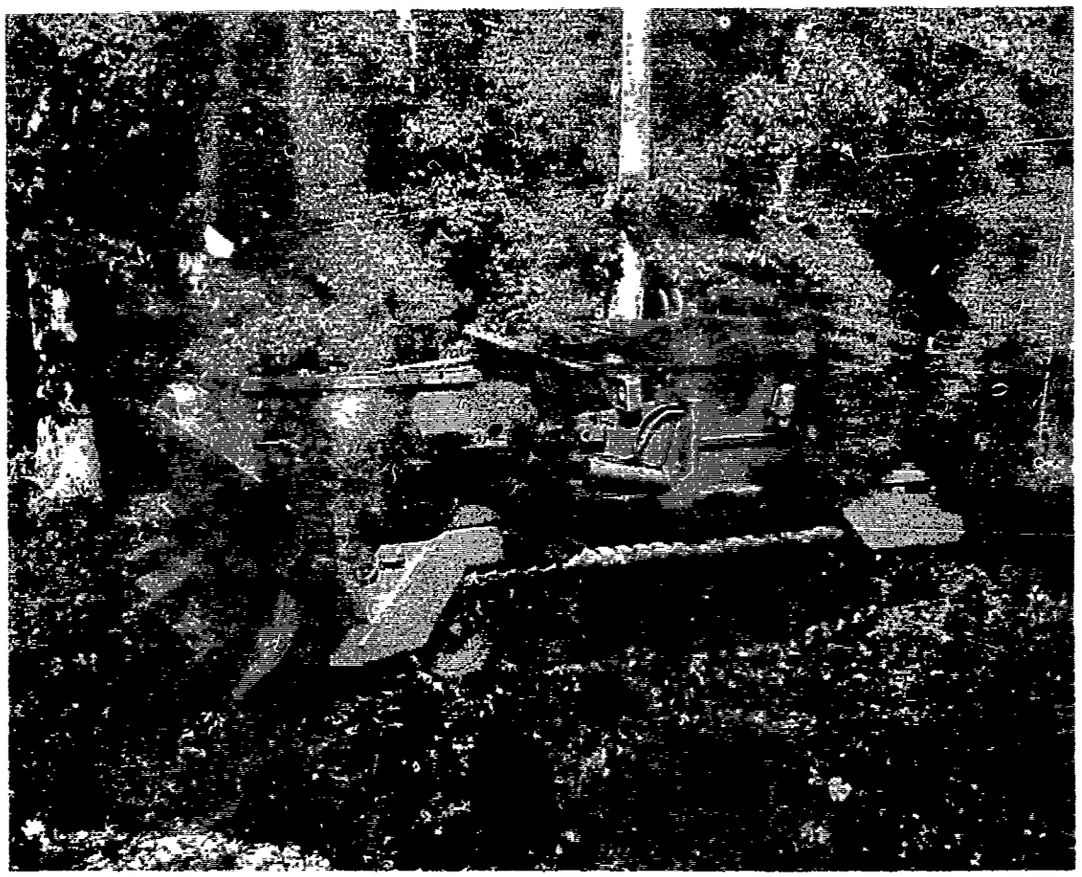


Figure IV-3. Armored Combat Earthmover (ACE)

missions in countermobility, survivability, mobility, and general combat engineering functions. Technological advancement must be generated and applied in lighter, multi-use and highly mobile equipment that can perform the basic construction tasks of earthmoving, surface treatment, site clearing and rock fragmentation at higher rates.

The current technology base is civilian industry oriented and was developed around cost minimizations for a given task. The equipment is designed for large commercial construction projects and is characteristically of single purpose, low mobility, and high weight.

Development of construction equipment for Army use has been very limited. The current fielded capability consists almost entirely of items purchased off-the-shelf with minor modifications for military suitability.

F. CONSTRUCTION EQUIPMENT SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

Engineering efforts within the Construction Equipment Engineering Division of the Mechanical Construction and Equipment Laboratory center on the preparation of technical data packages for Commercial Construction Equipment and MACI. In the field of endeavor the laboratory provides engineering support for quantity production of combat theater construction, earthmoving and clearing, and highway maintenance equipment.

2. Science and Technology Base Products and Activities

To address the deficiency cited earlier work continues on the M9 Armored Combat Earthmover (ACE) Vehicle including a demonstration of the ACE, an evaluation of its technical requirements, and the development and evaluation of other conceptual systems. In addition Rapid Deployment Force (RDF) needs will be assessed and a selected high performance earth mover system will be demonstrated. Figure IV-4 illustrates the schedule and funding profile.

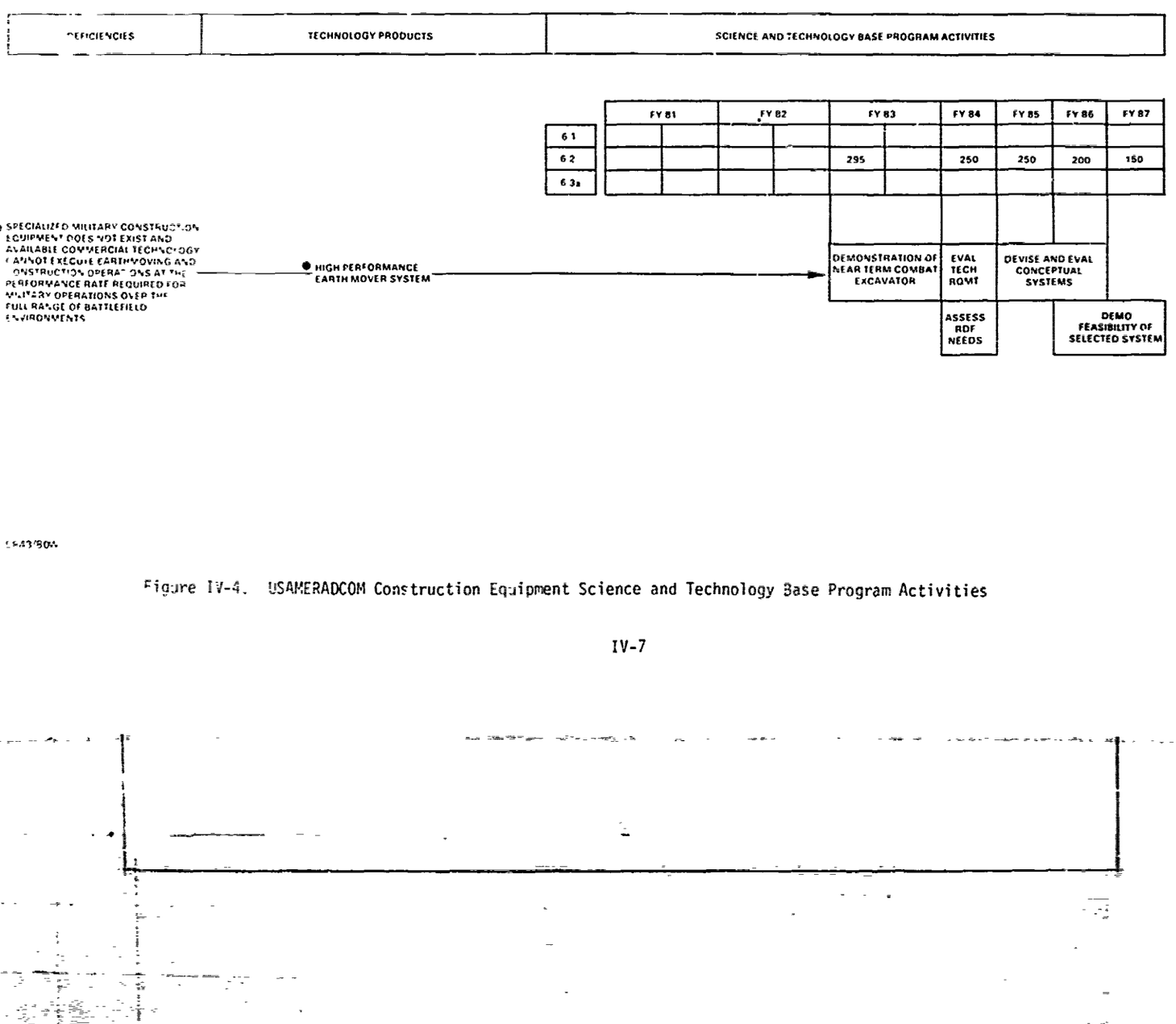


Figure IV-4. USAMERADCOM Construction Equipment Science and Technology Base Program Activities

CHAPTER V
FIELD FORTIFICATIONS

CHAPTER V

FIELD FORTIFICATIONS

A. MILITARY SIGNIFICANCE AND NEED

Field fortifications prevent threat forces--conventional, nuclear, and chemical warfare--from destroying US personnel and materiel, thus enabling US forces to inflict increased casualties thereby defeating larger threat forces. Field fortifications are constructed by personnel of all arms and services. Construction of defensive positions consisting of emplacements, entrenchments, and shelters can significantly decrease the attacker/defender force ratio necessary for success.

In offensive operations the critical period of the attack occurs during a short time after the seizure of the objective; rapid establishment of survivable initial defense positions by friendly forces will enable them to quickly consolidate the objective and present a formidable defense against the enemy counterattack.

B. FUNCTIONAL CHARACTERISTICS

The primary function of Field Fortifications is to provide protected fighting positions and shelters. This function involves the rapid emplacement of individual and crew-served weapon firing positions and the emplacement of large non-fighting shelters (e.g., command posts, aid stations, mess facilities, etc). Associated covers provide protection against nuclear, conventional, and chemical weapons attacks. Sub functions include the excavation of positions, providing cover and the use of accessories to detect underground obstructions.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet it's field fortification requirements consists of the existing equipment and activities presented in Figure V-1. Descriptions of each of these items are presented in Volume VI of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing field fortification capabilities are summarized below.

The primary fighting position emplacement capability is the soldiers' entrenching tool, and an explosive foxhole digger kit along with a fabric foxhole cover. The primary large shelter emplacement capability consists of various earthmoving dozers and the backhoe.

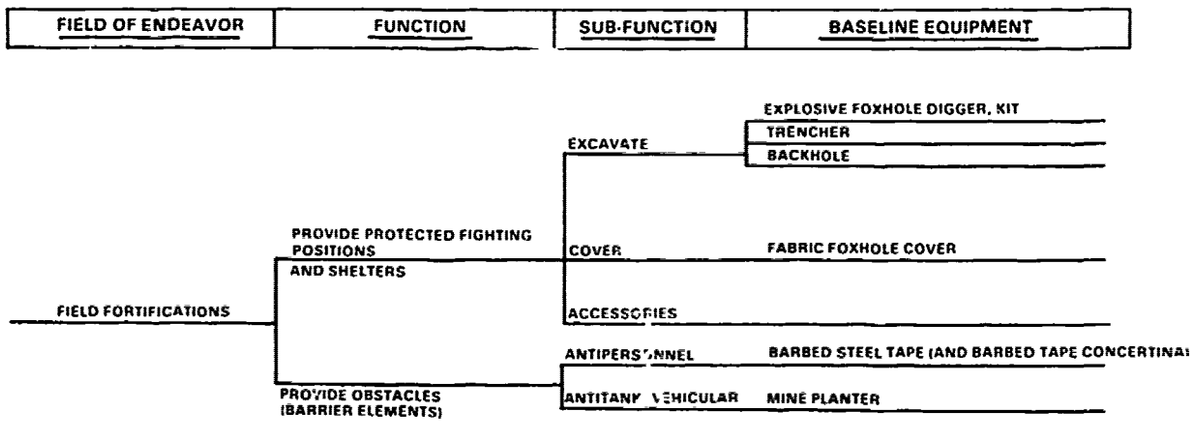


Figure V-1. Baseline Equipment Summary for Field Fortifications

D. ACQUISITION ACTIVITIES

Figure V-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI, and UNDI programs. At present, these are focused on such equipment as the Armored Combat Earthmover (ACE) (a full-tracked, high speed, armored dozer-scraper combination) for constructing large shelters and anti-armor obstacles; a three-way bucket attachment to front-end loaders to increase the rate of material handling; a tree spade to rapidly dig and cover combat fighting emplacements on the battlefield; a high speed earth excavator to rapidly dig excavations for the larger shelters required in the theater of operations. Acquisition activities also focus on equipment to provide cover such as the sand bagger, a hopper device that can rapidly fill hundreds of sandbags in an hour, shelter designs for small fighting emplacements; and the tree spade equipment mentioned above. Acquisition activities also include accessories such as electronic detectors to locate areas for excavation that are free of underground obstacles. Figure V-3 illustrates several devices for rapid excavation which are under development.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current field fortification capability versus needs has revealed the following two major deficiencies.

1. Construction of Field Fortification Requires More Time, Manpower and Logistic Support Than is Normally Available on the Modern Battlefield

Survivability on the modern battlefield depends on thwarting the enemy's target engagement process by increasing the mobility of friendly forces and providing them with adequate protective cover when under enemy fire. Heavy and bulky fortification equipment will limit battlefield mobility, and cumbersome construction techniques will not permit rapid emplacement of men and weapons to withstand enemy conventional, nuclear, and chemical attacks. Below-ground protection increases survivability, but current excavation equipment and techniques are too slow, and not enough of the construction equipment and material can be made available to the combat troops on the fast moving battlefield.

Field fortifications have been proven to be capable of substantially reducing the casualties and damage produced by all the weapons possessed by threat forces on the integrated battlefield. However, a review of the tactics and scenario prescribed by the Army for modern warfare

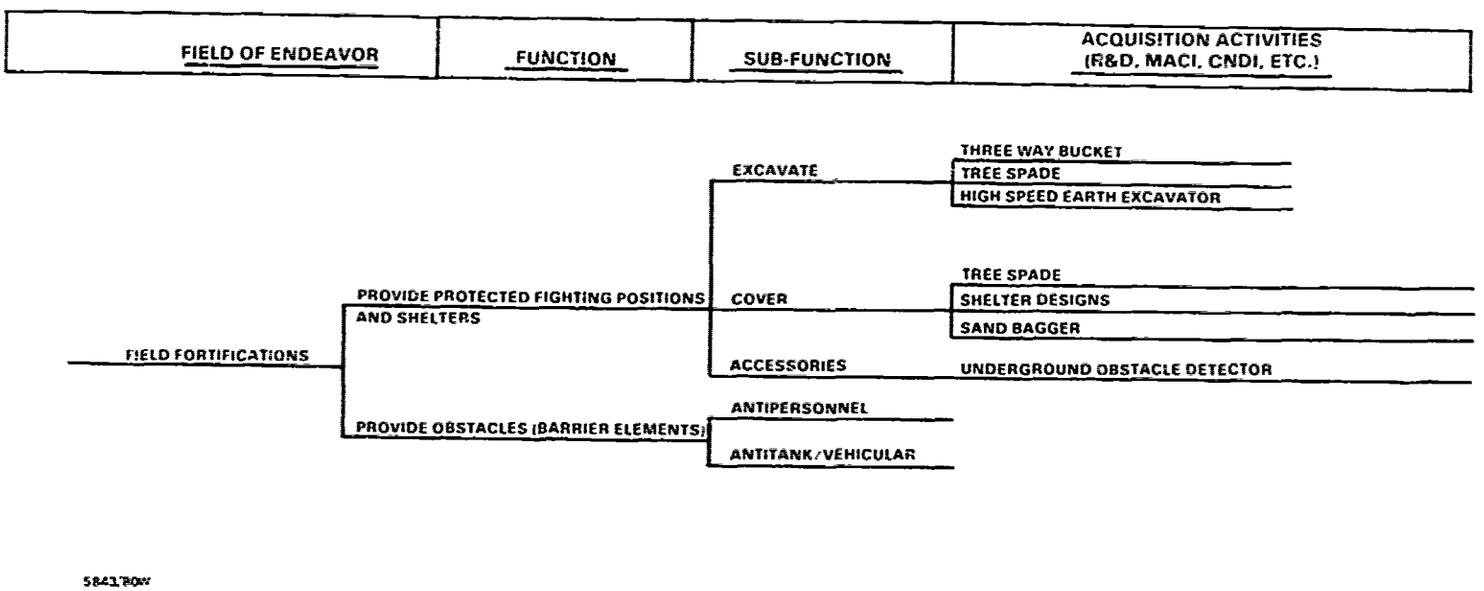
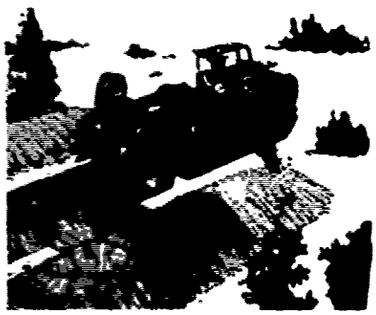
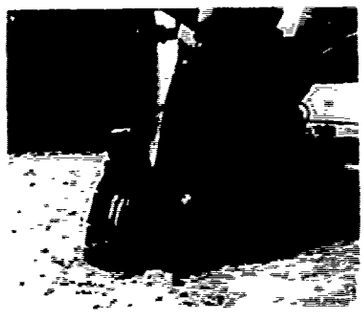


Figure V-2. Summary of Field Fortifications R&D Materiel Acquisition Activities

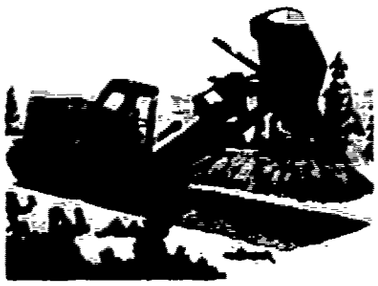


DOUBLE CHAIN

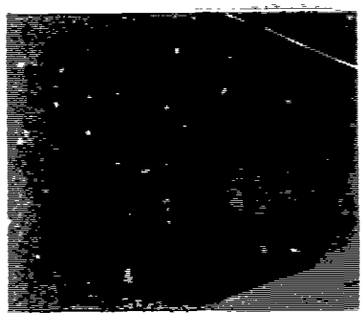


TREE SPADE

RAPID EXCAVATION



3 WAY BUCKET



DOUBLE DIPPER

Figure V-3. Developmental Devices For Rapid Excavation

has shown that excavation of adequate field fortifications cannot normally be completed within the available time by the available personnel and material resources. Existing excavating equipment continues to dig too slowly and has such low mobility capability that it is unavailable when and where needed. The excavations cannot be adequately enclosed so that they provide effective protection against primary threat weapons on the integrated battlefield without producing a prohibitive logistics and manpower burden. Current means to provide adequate protective cover against enemy conventional and NBC weapons can only be made at the expense of lightweight, rapid erection and disassembly fortification equipment required for highly mobile forces.

2. Data on Ballistic and NBC Protection Provided by Field Fortification is Not Adequately Integrated With Construction Requirements to Permit Operational Users to Determine How and When Field Fortifications Should Be Used

There is currently no basis for determining the requirements of field fortifications on the modern tactical battlefield by field operational personnel. The desirable characteristics of adequate protective cover under a wide range of operational situations should be evaluated and then technical guidance regarding field fortification requirements be provided to meet the operational conditions. The type and amount of field fortification equipment required by friendly combat forces needs to be measured against the enemy tactics, the type and capabilities of weapons to be employed, and the effects of various terrain and weather conditions.

F. FIELD FORTIFICATIONS SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of S&T efforts have been initiated. These initiatives show promise for advancing the capabilities of field fortifications in the combat area.

The phased research and development program is directed principally toward solutions that will fulfill the overall mission of developing a man/machine/hole/berm system for rapid excavation of a relatively shallow trench with controlled spoil deposits to produce an added protective berm.

Included will be advanced intelligent control systems which will reduce the physical dexterity requirement of the operator and will increase substantially the productivity of the machine operating under "intelligent" microprocessor programmable controls as compared with manual mode.

Technically, the risk of developing an acceptable Combat Emplacement Excavator is relatively low. Some commercial and allied nation equipment items are currently available which demonstrate some of the required characteristics in separate units. However, the unique characteristics required to excavate tactical emplacements with the desired speed does not exist in currently available items.

While the capability to excavate hull defilade positions for tank and fighting vehicles is marginally fulfilled by crawler tractors, the ability to dig smaller or more complex emplacements is presently lacking. The ACE and CEV both provide protection to the operators and have good mobility, but the proper relocation of excavated soil around the position is a problem. A combat emplacement excavator will reduce the digging shortfall to a more acceptable level.

The chain excavator with automatic spoil har (disposal) has been analytically determined to be the approach to meeting the operational need for rapid excavation of the required large (e.g., tank or artillery) field fortifications. The primary uncertainty is the ability of this technology to be able to produce the required size excavation.

Components and materials are being investigated to provide lightweight, low cost overhead ballistic protection for fighting and non-fighting positions. NBC protection, in addition to blast protection, is needed for fighting and non-fighting positions. Fighting positions will most likely rely on the individuals protective clothing and face mask, ... le large non-fighting shelters may include adaptations of existing collective NBC protection equipment.

Protective structural members will be designed for efficiency of logistics support, deployment, and function. These shelters will use earth cover as the main protective element and will be installed using rapid excavation equipment for hole preparation and cover deposition. Development of shelters for crew-served weapons and artillery is planned and these shelters will probably use technology similar to that of the anti-tank shelter and have similar characteristics.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products, together with the associated individual program activities, have been specifically instituted or planned to relieve the deficiencies discussed above in paragraph E. A graphic display illustrating the relationships and schedule is provided at Figure V-4.

a. Low Cost, Rapid, Small Fighting Position System

The product of this S&T effort will be a body of technical data and physical demonstrations of the value of truck and trailer-mounted excavators, composite materials for the cover of emplacements, and the development of concepts for protection against NBC. Specific activities in support of the product are as follows:

1) Demonstrate Low Cost Emplacement Excavator

The technology product will be a low cost high mobility rapid excavator for small fighting positions. The individual fighting position must be emplaced rapidly for increased survivability. This will be demonstrated both with a trailer and truck-mounted excavator that will dig and cover ar individual fighting position in less than five minutes.

2) Demonstrate the Fighting Position Enclosure

The technology product will be a foam structure and a fiberglass foxhole cover. They are designed to be lightweight, low cost, and will support 12 inches of soil and a contact burst of an 81mm mortar. They will be developed primarily to provide rapidly emplaceable shelters, supplying the necessary protection for the individual fighting position, the parapet foxhole, and the ATGM firing position.

b. Low-Cost, Rapid Large Shelter System

The products of this S&T effort will be physical demonstrations which show the value of high speed excavator equipment and large shelter structures. Technical data will include design specifications for the shelters. Specific activities in this regard are as follows:

1) Demonstrate the High-Speed Chain Excavator

The technology product will be a highly productive continuous excavator with a slewing double chain capable of digging emplacements from two to eighteen feet wide. All available horsepower and mass will be used continuously for excavation and spoils placement simultaneously, thereby reducing the size and power of equipment and on-site task time.

2) Demonstrate the 500 Cubic Yards per Hour Excavator

The technology product will be a physical demonstration of an improved highspeed combat excavator. By improving soil handling capability and tailoring excavation requirements, the performance of the high speed excavator can be increased to 500 cubic yards per hour.

3) Demonstrate the i500 Cubic Yards Per Hour Excavator

The technology product will be a physical demonstration of a combat emplacement excavator. Various fuel-air explosion devices will be utilized which are

designed to provide high energy release rates for the fracture and disaggregation of soil. Perfected means of soil handling devices will be employed along with the fuel-air explosion devices to demonstrate the rapid excavation of field fortifications.

4) Demonstrate Large Shelter Structure with Ballistic and NBC Protection

The technology product will be a physical demonstration of feasibility models. Models for the large non-fighting shelters will represent protective covers from ballistic and NBC attacks. Various shelter systems concepts will be selected to satisfy the need for protection of larger installations such as command posts, communications centers, and other non-fighting emplacements. These systems will be modular in design to provide flexibility of use. Emphasis will be placed on frame and fabric structures which can be constructed on site with minimal engineering support. These systems will use excavated earth instead of synthesized ballistic protection to provide protection from ballistic projectiles.

5) Shelter Design Specifications

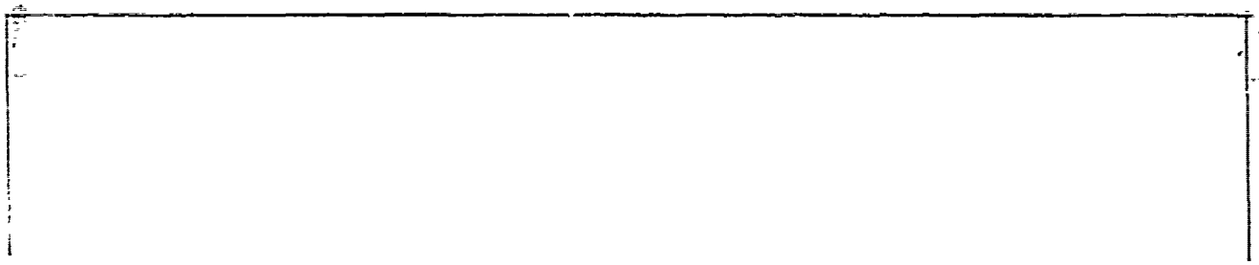
The technology product will be design specifications that integrate ballistic and NBC protection data with the construction requirements of the large shelter structure. Design specifications that relate the type of structure required to meet varying threat and operational conditions will enable Army units to determine when and how the large shelter structure should be used.

c. Field Fortification Technology and Application Handbook

The product of this S&T effort will be a body of technical data concerning the utilization and application of field fortification equipment and construction techniques. Specific activity in support of the product will be as follows:

1) Prepare Field Fortification Technology and Application Handbook

The technology product will provide a body of data in a handbook that will coordinate and integrate the various aspects of field fortifications under varying threat and operational conditions. The handbook will provide supporting reference data to construction personnel and planners on the proper use and application of field fortification items of equipment or technology.



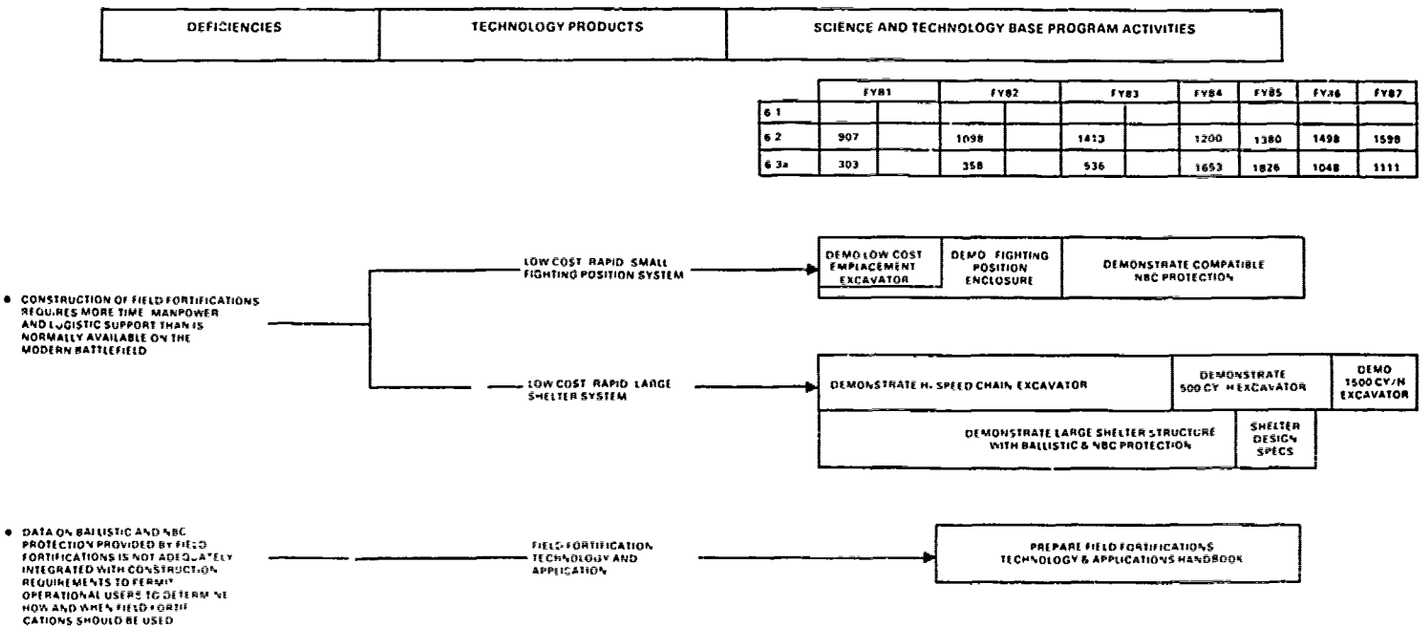
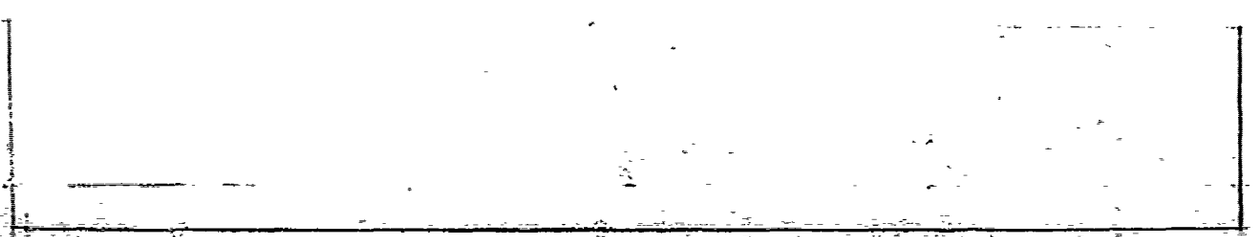


Figure V-4. USAMERADCOM Field Fortifications Science and Technology Base Program Activities



CHAPTER VI
CAMOUFLAGE

CHAPTER VI
CAMOUFLAGE

A. MILITARY SIGNIFICANCE AND NEED

Camouflage prevents enemy sensors from detecting/recognizing critical US battlefield operations. It also prevents advanced enemy sensors and high lethality weapon systems from effectively engaging US forces.

On the modern battlefield if a timely image (visual, IR, laser, acoustic, or radar) of a friendly target is presented to an enemy weapon, the target will be hit.

There is a need to provide maximum reduction in the susceptibility of Army personnel, equipment and materiel to detection, recognition, location, identification and acquisition, thereby enhancing their battlefield survivability.

B. FUNCTIONAL CHARACTERISTICS

Camouflage activities can be divided into the following four major functional areas.

1. Army-Wide Camouflage Activities

This function provides the Army with a lightweight camouflage screen system and the Army-wide pattern painting of tactical equipment. It also involves direct camouflage advice and assistance to operational users and development program managers. Camouflage standards and specifications for Army equipment and activities are related to threat sensor capabilities in order to achieve design goals to reduce enemy detection.

2. Signature Suppression

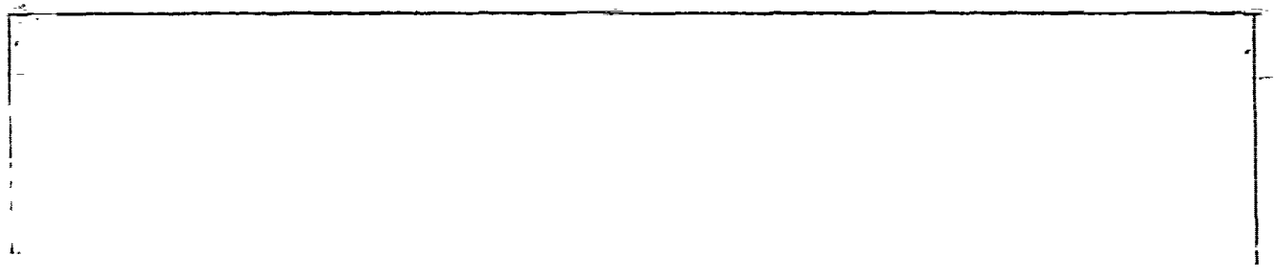
This function involves efforts to counter or deceive enemy visual, photographic, acoustic, laser, IR, and radar (MTI, Millimeter Wave and Centimeter Wave) surveillance systems.

3. Tactical Deception

This function provides the means to disguise Army equipment, personnel and activities by generating clutter that degrades radar detection, and by employing decoy devices that deceive enemy detection equipment.

4. Paints and Coatings

This function involves painting Army equipment with environmental background colors and patterns to reduce the visibility of the item from detectors operating in the near infrared as well as in the visual spectrum. It also involves coatings which are radar wave absorbent to degrade radar detection.



C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet its camouflage requirements consists of the existing equipment and activities presented in Figure VI-1. Descriptions of each of these items are presented in Volume VIII of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing camouflage capabilities are summarized below.

The primary signature suppression capability consists of the lightweight camouflage screens, woodland, desert, and snow systems, having either a radar transparent capability that does not interfere with radar transmission by the equipment beneath; or a radar scatter capability that prevents enemy radars from detecting the equipment. The primary paint and coating capability is an alkyd enamel compound, pattern-painted to distort the shape of the equipment, reduce contrasts with its background, and reduce glare while reflecting near infrared radiation.

D. ACQUISITION ACTIVITIES

Figure VI-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs. At present these are focused on thermal signature suppression and the disguise, decoys and clutter generation functions of tactical deception.

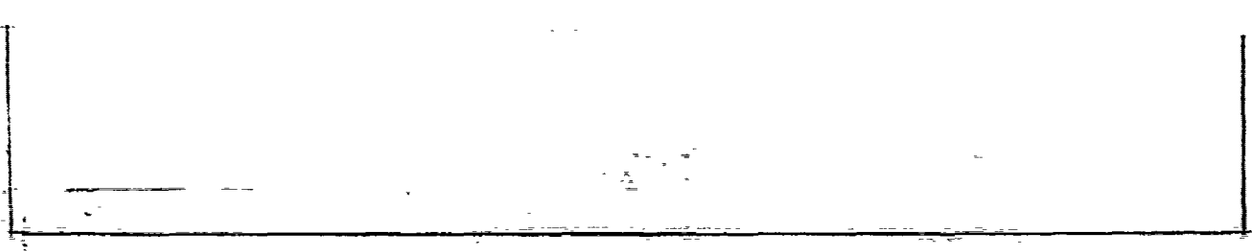
The thermal suppression kit is devised to suppress the thermal IR characteristics of engine (diesel) driven generators, a signature associated with critical battlefield targets such as data centrals, command posts and air defense sites.

As part of the tactical deception program, work is being performed to incorporate disguise and blend techniques so as to develop a decoy for the OH-58 helicopter, a high fidelity decoy for the M113 armored personnel carrier, a low fidelity inflatable decoy for the Hawk Air Defense weapon, and a bungee cord type decoy for the new Army tank. Radar corner reflectors are being investigated to generate clutter and false targets so as to deceive enemy radar operators.

Figure VI-3 shows the use of convertible camouflage netting to disguise a 155 mm M109 SP howitzer.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current camouflage capability versus current needs has revealed the following two major deficiencies.



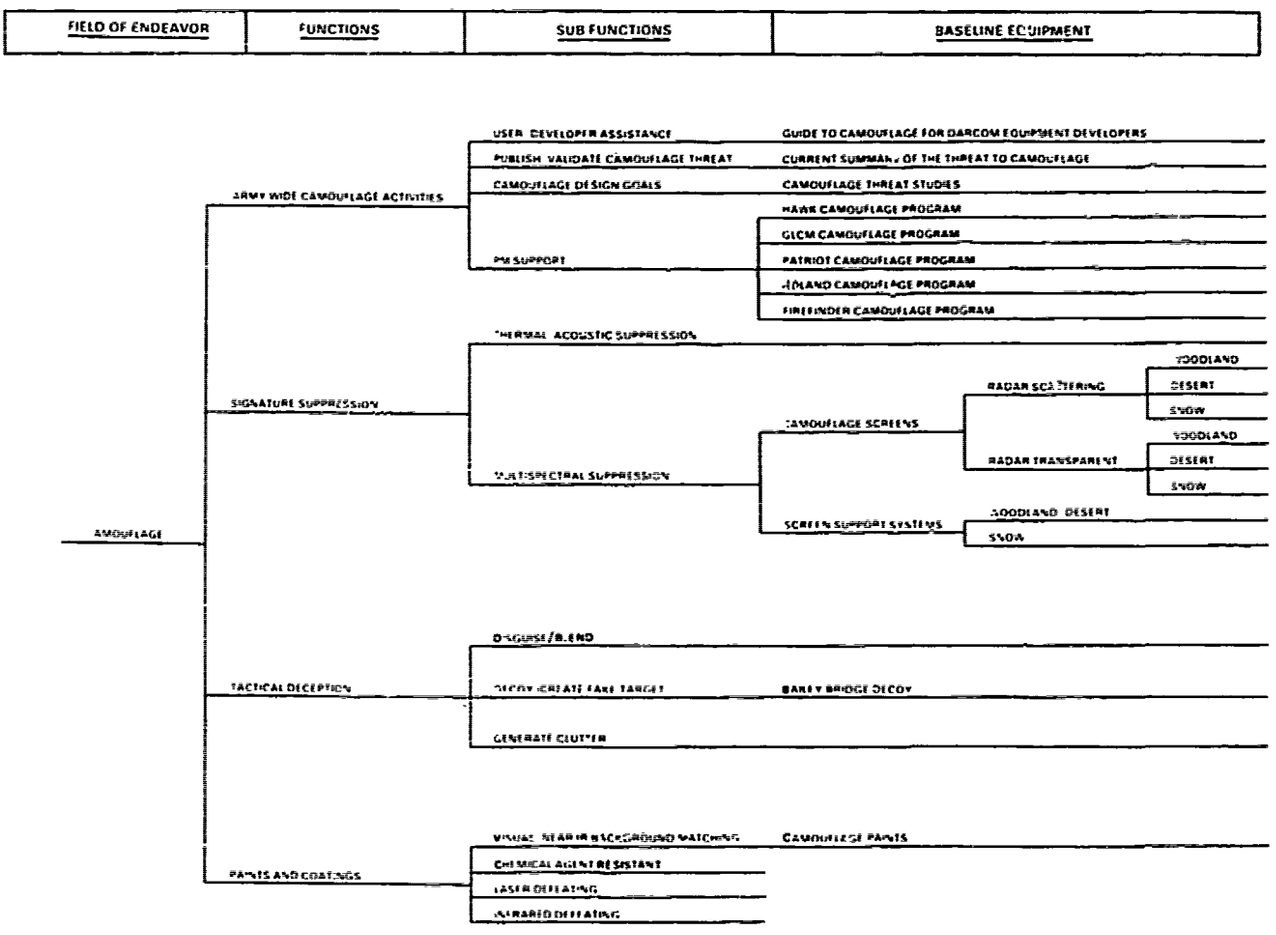


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Figure VI-1. Baseline Equipment Summary, Camouflage

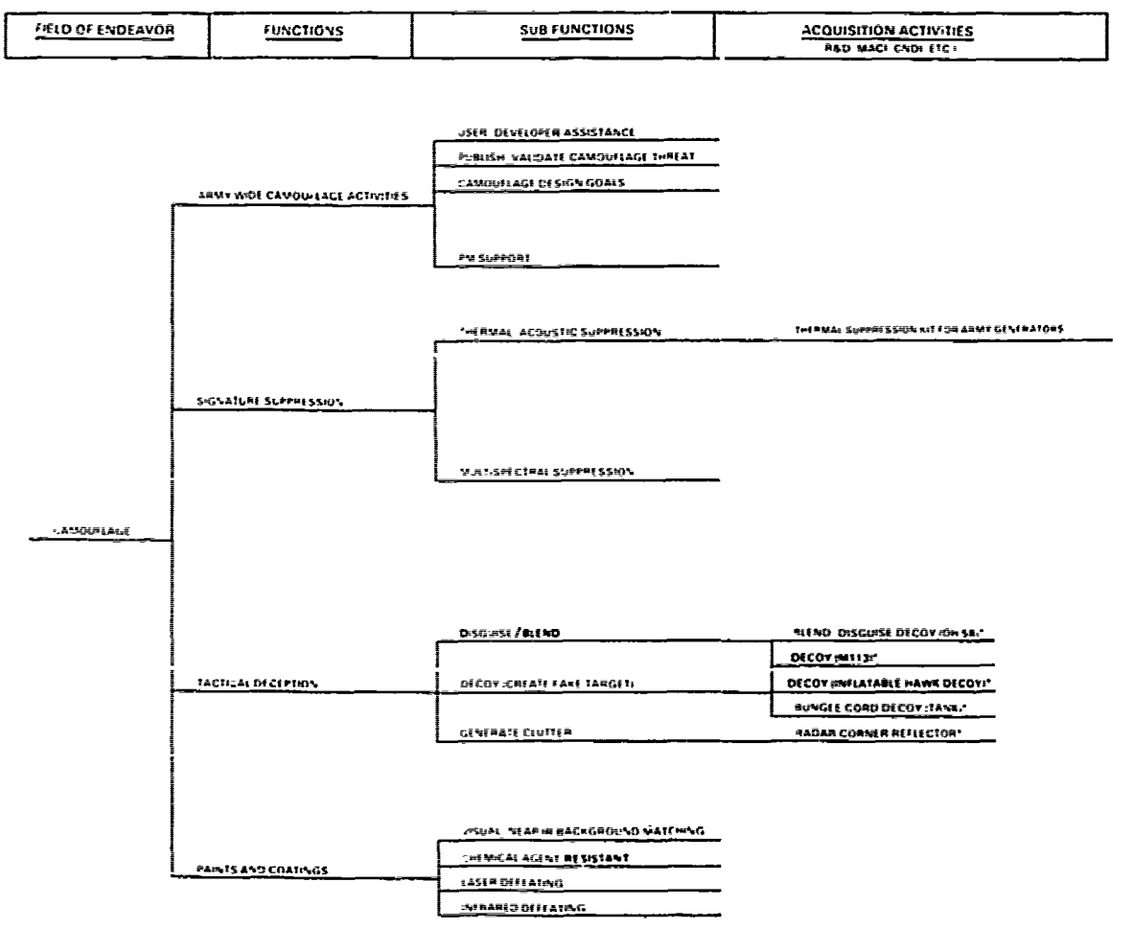

Figure VI-2. Summary of Camouflage R&D Materiel Acquisition Activities

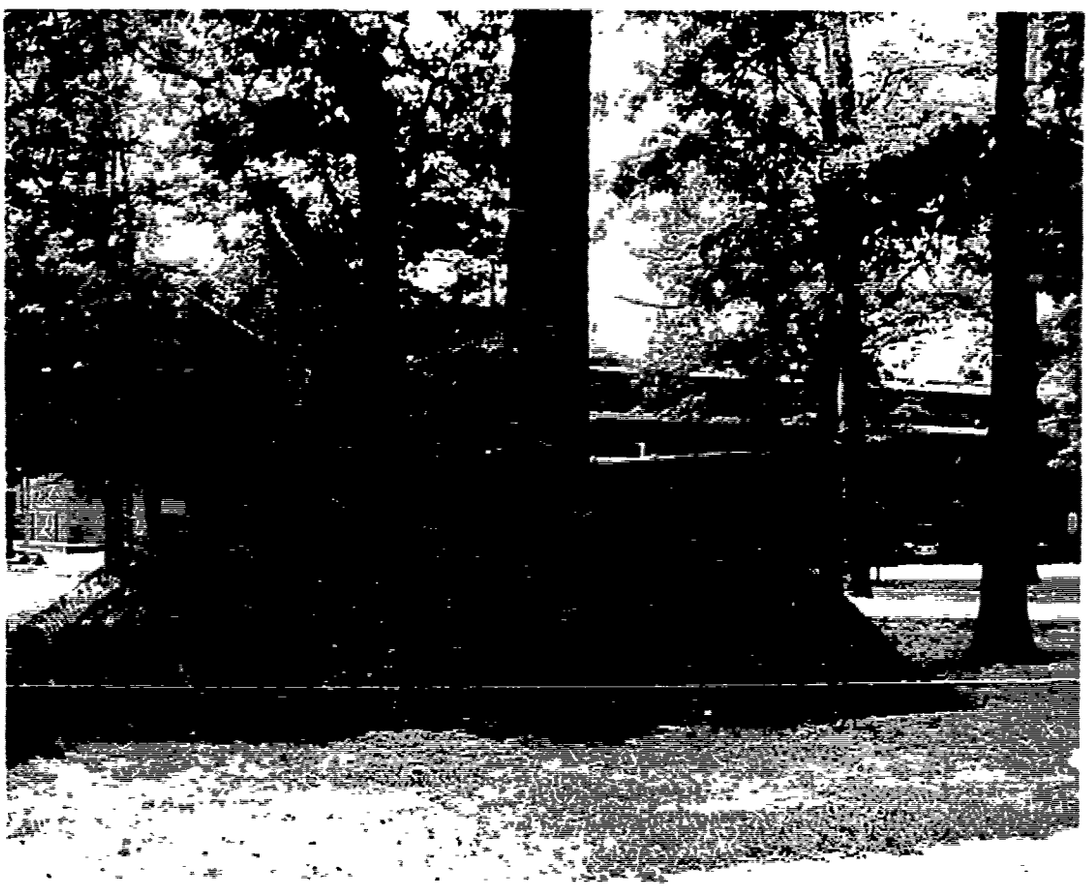

Figure VI-3. Convertible Camouflage Netting

1. Inability to Counter or Deceive Acoustic, Laser, Thermal IR, Radar MTI, and Radar Sensors

Camouflage pattern painting has been successfully employed for several years on mobility equipment throughout the US Army. Pattern painting has demonstrated its effectiveness as a camouflage technique in reducing the probability of target acquisition by air or ground visual observers or those using camouflage detection film.

It has been shown that these techniques while good in themselves have weaknesses in the face of improved hostile sensor technology. They provide no protection in the thermal infrared band or against laser rangefinders or designators. Their capability is limited against the latest hostile radars and they provide no protection against MTI radar, millimeterwave, or narrow band spectral threat sensors. Further, these techniques are not properly adapted to integration of protection in all of the wave bands. When viewed as a whole, the capability existing in the field today compared to the threat as validated by ACSI, shows the camouflage deficiency as stated.

2. Inability to Adequately Employ Tactical Decoy and Deception Maneuvers with Acceptable Operational/ Logistics Burdens

The United States Army today has no tactical decoy and deception material in the field and very little doctrine associated with it. Research has been done on decoy and deception techniques and a number of decoy prototypes have been built out of materials ranging from paper and plastic to inflatable materials. The problem is seen as being a joint DARCOM/TRADOC concern; since the ability to successfully employ tactical decoy and deception material requires successful tactics and doctrine.

F. CAMOUFLAGE SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of S&T efforts have been initiated. These initiatives show promise for advancing the capabilities of camouflaging the Army's personnel, equipment and activities.

Coatings form a complementary system to any camouflage net, and provide protection for the vehicle or item at all times especially while the vehicle is moving. Of particular importance is camouflage against laser rangefinders and laser homing weapons. This can be achieved through the use of a coating. Since September 1979, unique methods of electro-optical (EO) cross-section reduction of military hardware have been under investigation. The program entitled Laser and Visual Countermeasures has been directed toward passive means of cross-section reduction through the application of a specific type of chemical technology termed

ligand field chemistry. The goal of the program was the development of dyes or pigments which would absorb strongly and sharply at the Nd:YAG laser wavelengths yet be compatible with classical camouflage color so that visual contrast reduction and pattern breakup efforts would not be adversely influenced. To date this investigation has been successful in identifiying several different compounds which absorb at the Nd:YAG emission wavelength. Effort is continuing to identify still other compounds and to demonstrate heretofore idealistically hoped for results. Work to date has demonstrated that the technology may be attainable. Testing of synthetic materials and spectral examination of compounds in solution have been accomplished but not as a coating. The program envisioned for demonstrating the technical feasibility of incorporating these crown molecules into a coating would examine those compounds as they would be used under operational field conditions; that is, the compounds so identified would be further refined, purified, and incorporated into resin systems along with other pigments and additives to permit detailed study of their properties in paints and coatings. Then a coating matrix examination of retroreflectance at mono-static and bi-static angles would permit evaluation of their real potenti l as methods of EO cross-section control. The successful completion of this program would, in effect, allow laser invisible armored vehicles to fight on the modern battlefield.

During FY80 a rather extensive evaluation of radar camouflage concepts (camouflage against hostile radars) was conducted using scenarios from the Scores II System. Specific units representing different categories of ground targets were evaluated against several radar threats while using various radar passive countermeasures. This formed a matrix of radars, targets, and passive countermeasures which provided groupings for analysis. Out of more than 200 such combinations, the most significant 25 were evaluated for the performance of the radar, the performance of the passive countermeasure, and the military value of the overall cost and the logistic burden. Out of all of this analysis for the great majority of situations, clutter enhancement techniques and decoys or false targets proved to be effective methods of camouflage against radar. Therefore the program in the future will focus on retroreflectors of various kinds, scatterers (which include existing radar scattering lightweight screen), doppler spectrum spreaders, polarizers which change the polarity of the radar signal as it returns to the receiver, and radar absorbing material which is especially effective in the millimeter wave area. The continuing work will be devoted to further sorting out these techniques to settle on a small number, or possibly only one, which do the best overall job and can be demonstrable by FY87. The selected approach is first to initiate a

tactical deception program. A multi-national study is required to investigate the effectiveness of decoys in tactical employment. A successful completion of the overall plan will lead to additional requirements for funding for the second or execution phase which will be done later. The results of this study should be useful to the TRADOC community in establishing requirements for materiel as well as determining tactics and doctrine.

Active research in thermal and noise suppression of generators has been in progress since the early 70's. Experimental kits have been devised for the diesel, gas turbine and gasoline generator sets. Work was targeted against thermal sensors which were threats. The threat has been expanding at a rapid rate, however, and the current validated threat shows we have a long way to go to be able to counter it. Engine generator systems have large radar signatures because they are mounted on trucks and trailers. The radar cross section may be larger than for tanks. Detection/recognition of area targets (e.g., command posts) by radar may be a more significant threat than for thermal sensors - particularly since radar is here today.

Engine driven generator sets are listed as camouflage sensitive items. However, when camouflage sensitive items are used in combination with camouflage critical items they then become critical in themselves. Such is the case of generators when used with critical battlefield elements such as data centrals, command posts, and so forth. The objective, therefore, in camouflaging electric power generators is not to make them survivable but to make the units with which they are associated survivable. In continuing the research in the thermal infrared signature problem, it was found necessary to take a fairly substantial number of measurements both to find out accurately what the signature of the item on the ground is and how that signature appears to an airborne sensor. Many different sensors have been used. For example, at Fort Irwin, California, last fall the HMU-30 60 KW gas-turbine generator was used and looked at from the air with an Air Force aircraft fitted with an AAD-5 IR sensor (8-12u). In that experiment the suppression system used represented the state of the art in the 6.2 program. The suppressor did meet the specifications for signature reduction in that particular set of conditions with that particular instrument. At McClellan Air Force Base, HiCAMP sensors were used. These are much more sophisticated sensors and are employed in higher altitude aircraft. From this work the first quantified airborne measurements of thermal signatures were produced. That same HiCAMP platform was used again at Fort Hood and at the Naval Weapons Center at China Lake. Probably the biggest single measurement effort was work at Fort Hood from October of 1979 through

January of 1981. Based on this work and the insight it provides, a program for the thermal suppression of generators has been undertaken.

A search for a single integrated camouflage system titled Camouflage System 1986, or CS 86 for short, is being commenced. The particular reason for the selection of 1986 as a prototype target was the understanding that Division 86, the overall study of what tactical units will be doing in the field in about that time frame, is the background against which most development is currently targeted. During fiscal year 80 work was initiated to consider the matrix of equipment that must be camouflaged and the threats which will come against it. This is a continuation of the design goals program but oriented specifically toward a new camouflage system. It should be noted here that the new system may or may not look like the current screen. Work will start with the level of effectiveness of the current screen and proceed from there to provide as much of a counter to the threat as is possible. It is expected to be a system made up of shape disrupters of small pieces which are easier to handle. These are the challenging aspects that need to be examined so that camouflage requirements can be met at the least cost with minimum logistic burden and effort. The objectives for CS 86 include applicability to all Army tactical systems either stationary or moving (there is no camouflage capability against moving targets in the current inventory), ability to defeat sensors in all wavebands, and to defeat laser designators and rangefinders. The system must be modular and work in all seasons. These are the targets in CS 86 in the next five years and when achieved the Army will have a single integrated system which will have the ability to adequately counter laser, IR, radar MTI, millimeterwave, and narrow band multispectral threat sensors for a large part of Army targets.

One of the objectives of the camouflage research program is to develop a thin coating such as a paint that can be applied to surfaces of tactical equipment so that they cannot be distinguished from the natural thermal background (3-5.5u, 8-14u). Recent research has established that binders for the alkyd and polyurethane paints are limiting, i.e., regardless of how the pigment structure is varied, the thermal radiation properties of the paints at 8-14u are controlled by the binders.

A preliminary technical requirement for temperature differential of tactical equipment has been established to prevent its being distinguished from the natural background. This temperature differential is between the average effective surface temperature of the equipment and the average effective surface temperature of the immediate background. Thermal emissivity becomes a critical issue at the levels with which the project is dealing.

A computer model has been developed that enables the emissivity of complex paint mixtures to be calculated, assuming the optical properties (complex indices of refraction) are known. The latter depend upon the optical properties of each of the paint constituents. These include shape, chemical composition, amount, temperature, etc. In this program, the computer model will be used to guide the development of a thermal paint. Various binders will be tested, based upon this model. Similarly, various types of pigments will be tested. Optical properties of the individual pigments will then be measured as appropriate.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in paragraph E. A graphic display illustrating the relationships and schedule is provided at Figure VI-4.

a. Anti-Laser Paint

The products of this S&T effort are physical demonstrations of the value of using coating compounds to complement camouflage systems and provide design specifications for absorption compounds. Specific activities to determine the absorption characteristics of various additives at specified Laser wave lengths are as follows:

1) Demonstrate Crown Molecular Shield

This product will demonstrate the technical feasibility of incorporating a crown molecular compound into a coating and to examine these compounds as they would be used under field conditions.

2) Demonstrate Crown Molecule "Paint"

The product will provide a detailed study of incorporating crown molecule compounds that have been refined and purified into resin systems along with other pigments and addenda. Study will evaluate the laser wavelength absorption properties of the compound in various paints and coatings to determine their real potential as electro-optical cross section control.

3) Design Specifications for Crown Molecule Paint

Product will provide specifications for camouflage paints with various additive compounds at specified laser wave lengths.

b. Radar Camouflage System

The products of this S&T effort will be physical demonstrations of the value of using various materials to provide passive countermeasures against enemy radar

signals. Specific activities in this regard are as follows:

1) Demonstrate Basic Corner Reflector

Experimentally demonstrate clutter enhancement capability of corner reflectors on military equipment, and focus on various kinds of retroreflectors and scattering material to reduce the radar signature from moving vehicles.

2) Demonstrate "Doppler Spectrum Spreading" Corner Reflector

Experimentally demonstrate the scattering of radar signals by spreading the doppler frequency shift emitted by a moving vehicle. Corner reflectors emit a strong signal that distorts the signal received by the threat sensor, denying accurate radar surveillance and target acquisition information to the enemy.

3) System Integration of Radar Camouflage Components

Various techniques for reducing the moving target signatures will be sorted out to produce a small number (or perhaps one) which perform best overall in denying surveillance information to the enemy.

4) Operational Demonstration of Selected Camouflage System

A demonstration in a field environment of the items and materiel best suited for reducing the moving target signatures of various military vehicles. Emphasis on field reliability will focus attention on the formulation and approval of operational demonstration plans.

5) Design Specifications for Radar Camouflage System

During preparation of the system specifications, effort will be made to insure that specified goals for reducing moving target signatures are within the design state of the art. Initial reliability and maintainability requirements will be stated as a basis for later use in the Conceptual Formulation Package.

c. Generator Acoustic Camouflage System

The products of this S&T effort will be physical demonstrations of the value of using various materials to provide passive countermeasures against threat acoustic and IR detection devices. Specific activities in this regard are as follows:

1) Demonstrate Integrated Acoustic/IR Camouflage

Experimentally demonstrate the feasibility of integrating noise and IR camouflage measures using selected military items of equipment. Substantial number of measurements will be taken to determine characteristics of the item's signature on the ground and later how that signature appears to an airborne sensor.

2) Demonstrate the Application of Integrated Camouflage to Gas Turbine/ Diesel Engines

An evaluation of experimental kits devised to provide camouflage of both the noise and IR signatures associated with diesel gas turbine and gasoline sets.

3) Design Specifications for a Generator Acoustic Camouflage System

The product of this effort will be a body of design specifications reflecting the minimum military performance requirements for the camouflage system. Design details will relate to reliability and maintainability standards required to meet performance goals for suppressing acoustic and IR signatures.

d. Modular, Multi-Spectral Camouflage System

The products of this S&T effort will be the development of a prototype, single integrated camouflage system for most (if not all) Army tactical systems, either stationary or moving. Specific activities are as follows:

1) Define The Technical Requirements for a Modular, Multi-Spectral Camouflage System

A continuation of design goals oriented specifically toward a new camouflage system. A matrix of Army tactical systems to be camouflaged will be compared with the threat sensors expected to be employed against each system. Analysis will lead to the technical performance requirements for a single integrated camouflage system.

2) Devise New Camouflage System Technical Concepts

The determination of technical requirements for a prototype item that can counter as much as possible the capabilities of threat sensors. Development concepts must include means to defeat sensors in all wavebands; to defeat lasers and range finders; and must be modular and work in all seasons.

3) Demonstration of the Feasibility of Components for a Multi-Spectral Camouflage System

A physical demonstration to show the capability of various modular components of a development prototype against various threat sensors.

4) Synthesize Capabilities of Modular Components for Multi-Spectral Camouflage System

Modular components that suppress signatures susceptible to threat sensor capabilities will be combined to produce a new multispectral camouflage product. Techniques of each modular component will be properly adapted to integration of protection in all the wavebands.

5) Demonstration of the Feasibility of a Synthesized Modular, Multi-Spectral System

A demonstration of synthesized modules for a general purpose camouflage system. Integrated suppression of the multi-spectral signatures of various items of military equipment will be measured against the detection, location and identification capabilities of various threat sensors.

6) Design Specifications for the Modular, Multi-Spectral Camouflage System

The product of this effort will be a body of specifications reflecting the minimum performance requirements for the integrated system. Design details will include better physical design of the various modular components.

e. Thermal/IR Camouflage System

The products of this S&T effort will be demonstrations of devices and equipment that suppress the thermal and IR signatures of tactical equipment. Specific activities are as follows:

1) Demonstrate the Active Plate Suppressor Concept

A feasibility demonstration using a modular prototype for suppression of thermal/IR signatures. Equipment system consists of dual surface combined with an air cooling effect to alternate signatures.

2) Demonstrate Plate-Suppressor on Generators and Vehicles

A demonstration to show the suitability of Plate-Suppressors for application to camouflage sensitive generators and camouflage critical vehicles.

3) Synthesize An Active Plate Suppressor Configuration

Modular components that suppress signatures susceptible to threat sensor capabilities will be combined and tested to determine compatibility of the components with equipment camouflaged.

4) Demonstrate the Active-Plate Suppressor System

A demonstration of the Active-Plate Suppressor System on camouflage critical Army equipment against airborne infrared sensors.

5) Demonstrate the Passive IR Screen Concept and Enhanced Bluefish

An experimental demonstration of passive IR/thermal camouflage techniques against airborne sensors with a long range detection/recognition capability. Both airborne and local (ground) measurements of temperatures and other relevant parameters will be made to determine the effectiveness of a Passive IR Screen.

6) Demonstrate Passive IR Sensor on Generators and Vehicles

A demonstration of prototype passive IR camouflage kits for the turbine and diesel generators used in selected camouflage critical items of Army equipment.

DEFICIENCIES	TECHNOLOGY PRODUCTS	SCIENCE AND TECHNOLOGY BASE PROGRAM ACTIVITIES

	FY81		FY82		FY83		FY84	FY85	FY86	FY87
6.1	140	14	250	75	300	30	300	300	300	300
6.2	961	300	1030	77	1212		1371	1325	1438	1535
6.3a										

- INABILITY TO ADEQUATELY COUNTER OR DECEIVE LASER, IR, RADAR, MTI, JAM/WAVE, AND NARROW BAND MULTI SPECTRAL THREAT SENSORS
  - [illegible] LASER PAINT → DEMO CROWN MOLECULE SHIELD → DEMO CROWN MOLECULE PAINT → DESIGN SPECS CROWN MOLE PAINT
  - MTI RADAR CAMOUFLAGE SYSTEM → DEMO BASIC CORNER REFLECTOR → DEMO DOPPLER SPECTRUM SPREADING CORNER REFLECTOR → INTEGRATE SYSTEM → OP DEMO → DESIGN SPECS
  - GENERATOR ACOUSTIC CAMOUFLAGE SYSTEM → DEMO INTEGRATED ACOUSTIC/IR CAMO → DEMO APPLICATION OF INTEGRATED CAMOUFLAGE TO GAS/DIESEL ENGINES → DESIGN SPECS
  - MODULAR MULTI SPECTRAL CAMOUFLAGE SYSTEM → DEFINE TECHNICAL REQUIREMENTS → DEVISE SYSTEM TECH CONCEPTS → DEMO FEASIBILITY OF SYSTEM COMPONENTS → SYNTH SYSTEM → DEMO SYSTEM FEAS → DESIGN SPECS
  - THERMAL IR CAMOUFLAGE SYSTEM → DEMO ACTIVE PLATE SUPPRESSOR CONCEPT → DEMO PLATE SUPPRESSOR ON GENERATORS AND VEHICLES → SYNTH SYSTEM → DEMO SYSTEM
    - DEMO PASSIVE IR SCREEN CONCEPT & ENHANCED BLUEFISH
    - DEMO PASSIVE SCREEN ON GENERATORS AND VEHICLES
- INABILITY TO ADEQUATELY EMPLOY TACTICAL DECOY AND DECEPTION MANEUVERS WITH ACCEPTABLE OPERATIONAL LOGISTICS BURDENS → (R&D ACTIVITY NOT PROGRAMMED)

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Figure VI-4. USAMERADCOM Camouflage Science and Technology Base Program Activities

CHAPTER VII
PHYSICAL SECURITY

CHAPTER VII
PHYSICAL SECURITY

A. MILITARY SIGNIFICANCE AND NEED

Physical security systems protect stored military equipment, supplies and sensitive material, to include data, reports, etc., from theft, sabotage or espionage.

Timely availability of equipment and supplies at the critical location are essential for the US Army to be successful on the battlefield. The safeguarding of classified information stored in rear area installations is also critical to the success of the US armed forces in combat.

B. FUNCTIONAL CHARACTERISTICS

Physical security can be divided into the following six major functional areas:

1. Detect Intrusion

This function involves the detection of armed personnel, intruder penetration and movement, wheeled and tracked vehicles, and metal weapons.

2. Process Information

This function involves monitoring alarm information, activating response devices, and providing data links and communications interface. The principal subdivisions of this function are Control and Interface.

3. Communicate

This function provides for the sensing, interpretation, and transmission of data to alarm systems.

4. Display Data

This function provides for the display of alarm information via maps, graphic forms, auditory signals, and closed circuit T.V.

5. Deter Intrusion

This function provides for deterrence to forcible and surreptitious entry through the use of security padlocks, barbed tapes, and hasps. The two principal subdivisions of this function are Lock and impede.

6. Alert Guards

This function provides a method by which guards can quickly locate the protected area under attack. Figure VII-1 depicts a typical intrusion detection site configuration.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet its physical security requirements consists of the existing equipment presented in Figure VII-2. Descriptions of each of these items are presented in

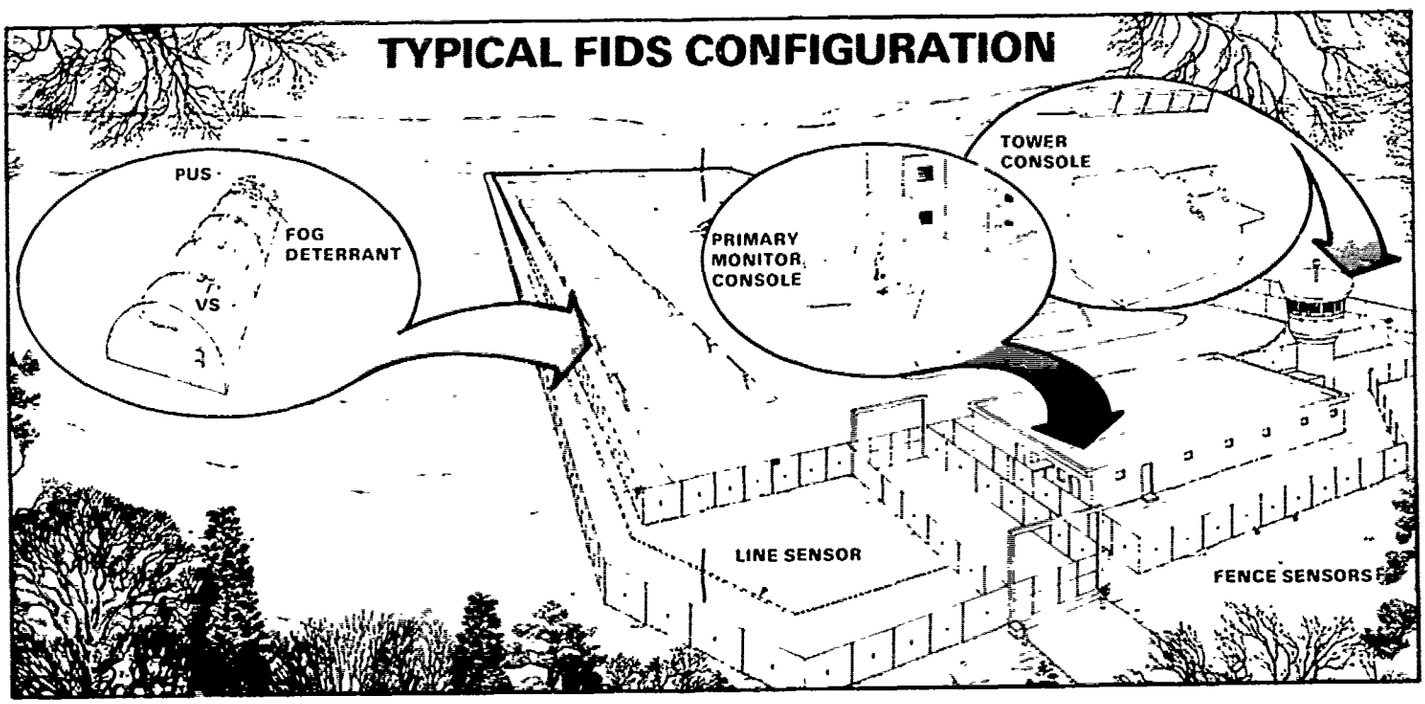


Figure VII-1. Typical FIDS Configuration

Volume VI of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing physical security capabilities are derived from the fielded Joint-Services Interior Intrusion Detection System (J-SIIDS) and are summarized below and in Figure VII-2.

1. Detect Intrusion

a. Detector, Vibration, Signal, J-SIIDS

The sensor consists of a Vibration Signal Processor and one or more Vibration Signal Detectors and detects structurally transmitted vibrations imparted to a metal barrier by actions such as burning, sawing, drilling, and hammering. The sensor generates an alarm when the energy generated satisfies certain design criteria.

b. Sensor, Capacitance, Proximity, J-SIIDS

The Capacitance Proximity Sensor (CPS) is designed to detect penetration through windows, ventilators, and other similar openings. The sensor continually monitors the net capacitance between sensor protected metal objects and a reference ground. When used as a penetration sensor, the metal objects consist of metal grills which are insulated from ground and mounted over the openings.

c. Sensor, Gridwire, J-SIIDS

The Gridwire Sensor consists essentially of two continuous wires in a four-inch square grid pattern which cover a barrier. Wood panels are installed over the wire grid to protect and conceal the grid. Penetration of the barrier breaks the wire at one or more points and causes an intrusion alarm to be generated.

d. Switch, Alarm, Latching, J-SIIDS

This is a duress alarm which can be mounted to the wall or floor close to personnel stations and can be hand or foot operated.

e. Switch, Balanced, Magnetic, J-SIIDS

The Magnetic Switch is mounted on a door or window to detect opening of the door or window. When the door or window is closed, the magnetic field is balanced and the switch is allowed to close. When the door or window is opened the field becomes unbalanced and forces the switch to open initiating an intrusion alarm si

f. Sensor, Magnetic Weapon, J-SIIDS

The sensor detects disturbances in the ambient magnetic field caused by motion of the ferrous weapon in the vicinity of the sensor ' pwire. The sensor consists of a signal processor and a wi op positioned on the weapons rack behind the weapons.

g. Sensor, Ultrasonic, Motion Signal, J-SIIDS

The Ultrasonic Motion Sensor detects the motion of an intruder inside a protected area. A receiving transducer receives a reflected signal, and it is compared to the transmitted signal. If no motion exists within the protected room the received and transmitted signals are at the same frequency. Motion, however, causes the reflected

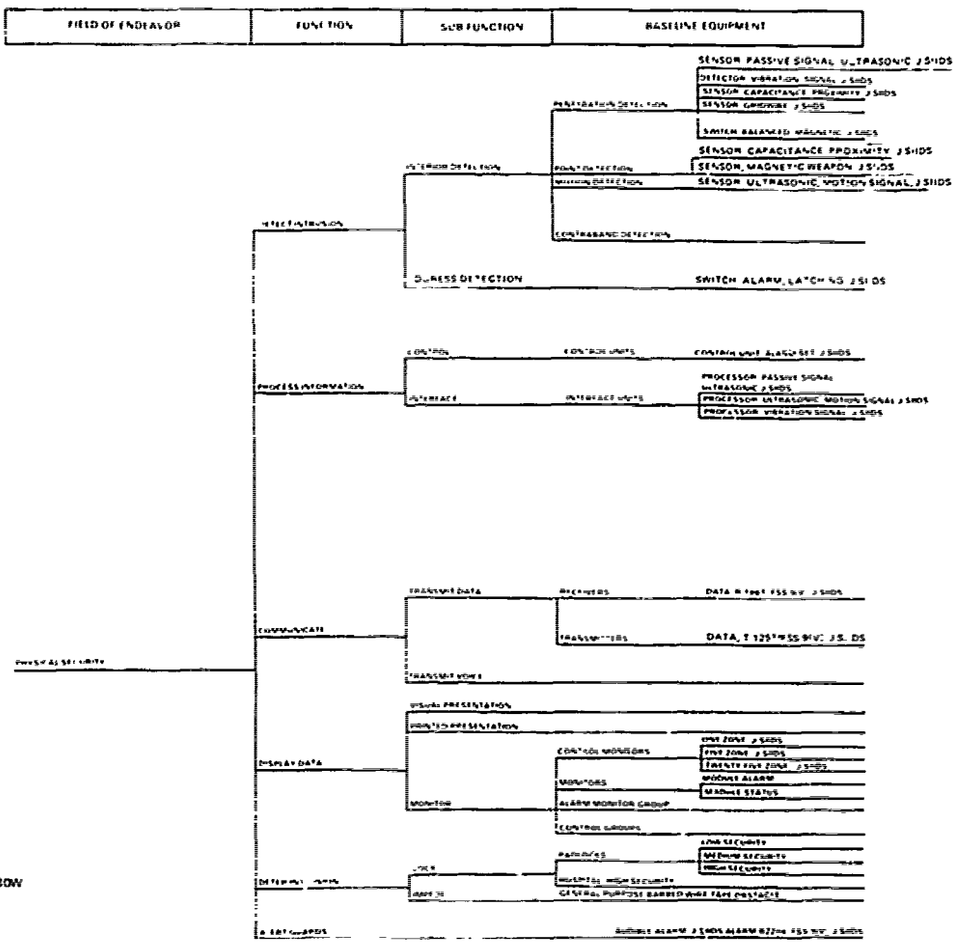


Figure VII-2. Baseline J-SIIDS Equipment Summary for Physical Security

signal to shift in frequency from the transmitted signal and an alarm signal is generated.

h. Sensor, Passive Signal, Ultrasonic, J-SIIDS

The Passive Ultrasonic Sensor is designed to protect against forced entry through metal and masonry walls, ceilings, and floors and through metal doors, metal mesh, and barred or shuttered windows and ventilation openings when these openings are properly sealed against outside sounds. The sensor detects repetitive ultrasonic energy that is generated when a penetration is attempted through tnese barriers by sawing, hammering, drilling, or burning with a torch, and alarms when the energy generated satisfies certain design criteria.

2. Process Information

a. Control Unit, Alarm Set, J-SIIDS

The Control Unit is the central control element of the J-SIIDS and is located within the protected area. It receives and processes the intrusion, tamper, and duress alarm signals generated at the sensors, provides for selection of the mode of operation of the system, and continuously presents the status and mode of operation to the Alarm Monitor Group.

b. Processor, Passive Signal, Ultrasonic, J-SIIDS

The Passive Ultrasonic Signal Processor and the Passive Ultrasonic Signal Receiver comprise the Passive Ultrasonic Sensor. Up to 20 receivers can be connected to one signal processor to achieve large area coverage.

d. Processor, Ultrasonic, Motion Signal, J-SIIDS

The Ultrasonic Motion Signal Processor and the Ultrasonic Motion Signal Transceiver comprise the Ultrasonic Motion Sensor. Up to 20 Ultrasonic Motion Signal Transceivers may be used with one Ultrasonic Motion Signal Processor. The signal processor compares the reflected signal from the receiving transducer to the transmitted signal. Motion in the protected area causes the received signal to shift in frequency from the transmitted signal. The signal processor detects this frequency change and initiates an alarm signal when design criteria have been met.

e. Processor, Vibration Signal, J-SIIDS

The processor is used in conjunction with the Vibration Signal Detector. Up to 20 detectors can be connected to one processor.

3. Communicate

a. Data Receiver, R-1861/FSS-9(V), J-SIIDS

The Data Receiver is connected to a monitor module mounted in the Monitor Cabinet. The Data Receiver operates in conjunction with the Data Transmitter over a maximum of 10 miles of 600 ohm, 2-wire, balanced transmission line, or over telephone systems using dedicated voice-grade lines. The Data Receiver decodes information received

from the transmitter and presents it to a monitor module for display.

b. Data Transmitter, T-1257/FSS-9(V), J-SIIDS

The Data Transmitter is mounted in the Control Unit. The Data Transmitter continuously transmits the alarm status of the protected area, the status of a.c. power at the Control Unit, and the system mode of operation. Secure signal transmission is achieved through the use of synchronized pseudorandom b nary sequence generators in the transmitter and receiver.

4. Display Data

a. Monitor Cabinet, 1 Zone, 5 Zone, 25 Zone, J-SIIDS

The Monitor Cabinet houses a Signal Module which reports the status of Monitor Cabinet a.c. power and gives an audible signal when the power supply status changes, and Alarm and Status Monitor Modules that report the status of the protected areas. The Monitor Cabinet has self-contained primary and back-up power which is automatic and instantaneous if a.c. power fails. Three types or sizes of Monitor Cabinets are available: a single zone with provisions for one plug-in monitor module; a five zone with provisions for up to five monitor modules; and a 25 zone which accepts up to 25 monitor modules.

b. Module Alarm, Status

The Status Monitor Module displays system ALARM, SECURE/ACCESS, and AC POWER status conditions. Each status change is also accompanied by an audible tone from the Monitor Cabinet.

5. Deter Intrusion

a. Low Security Padlock

These locks are called out for use in applications having nominal resistance to forcible entry (no minimum time specified) and from 40 to 60 seconds of resistance to picking. These locks are frequently specified for use on perimeter fence gates and gun racks in armories. Padlocks covered by this specification are of three grades.

b. Medium Security Padlock

These locks are essentially the same as the M , 831 except that the shackle is not protected by an tegral shroud. They provide the same resistance to surreptitious entry as the Model 831 described below, but are less resistant to forcible entry because of the exposed shackle.

c. High Security Padlock

Military Specification MIL-P-43607D sets the highest level of performance for any of the key operated padlocks specified for use by the DOD. The only lock currently procurable under this specification is the Sargent

and Greenleaf (S&G) Model 831B shrouded shackle padlock. This lock has a throat height opening of approximately 21/32 inch.

6. Alert Guards - Audible Alarm, J-SIIDS Alarm B2-204/FSS-9(V)

The Audible Alarm is normally mounted on the exterior wall of a building. Because of its location, the Audible Alarm is relatively vulnerable, but complete protection against tampering is provided.

D. ACQUISITION ACTIVITIES

Identified in Figure VII-3 are current R&D materiel acquisition activities generated from R&D, MACI & CNDI programs. At present these activities are focused on J-SIIDS add-ons, the Facility Intrusion Detection System (FIDS), and the Remotely Monitored Battlefield Sensor System (REMBASS). The FIDS is a highly secure microprocessor controlled system being developed by the Army for joint service applications. This system will provide physical security for DOD installations against a wide variety of threats. The REMBASS is an unattended ground sensor system that will detect and classify intruding personnel and vehicles.

E. CURRENT CAPABILITY DEFICIENCIES

The Army's current capabilities versus current requirements in the field of Physical Security reveals two major deficiencies.

1. The Army is unable to detect, locate, and neutralize intrusion, espionage, and sabotage attempts against fixed facilities and sensitive materiel during transit or while stored in temporary sites on rear area of the battlefield with the desired degree of reliability within reasonable and available manpower resources

The theft of cargo during transit or temporary storage has been accepted and charged off as a part of the cost of transportation for many years. Studies of commercial shipments have shown losses of three to five percent from theft. Reports of thefts up to an entire train are alarming, but in a tactical situation even small losses may be critical.

There also exists a severe inability to detect, locate, and neutralize attempts to steal, sabotage, or compromise sensitive and/or expensive material during transit reliably with reasonable manpower resources available for this purpose.

2. The False Alarm Rate for Many Sensors is Unacceptable

Many sensor types are activated by natural phenomena in the environment, such as lightning, thunder, hail, wind, air currents from space heaters, motion of curtains,

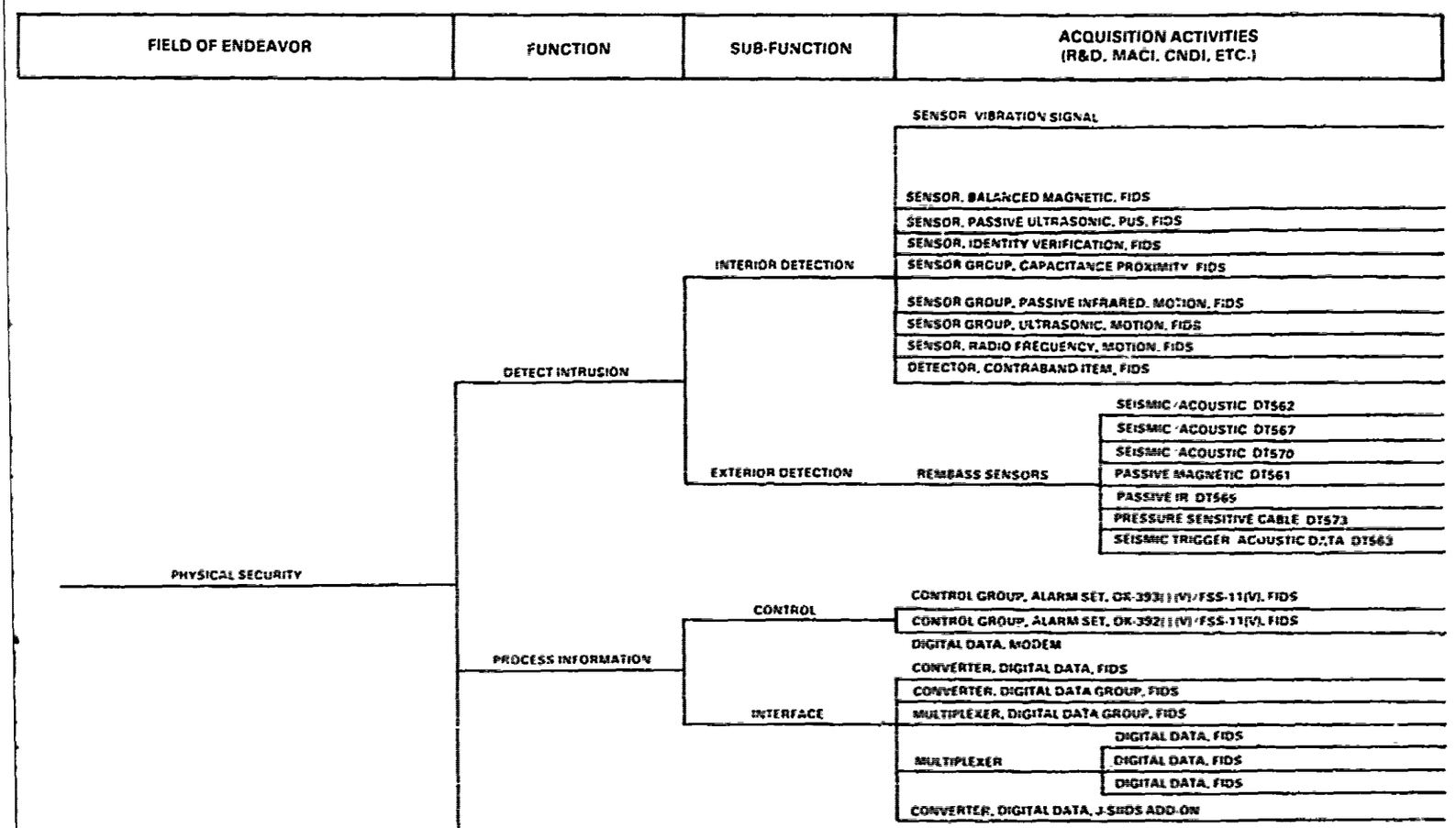


Figure VII-3. Summary of Physical Security R&D Materiel Acquisition Activities

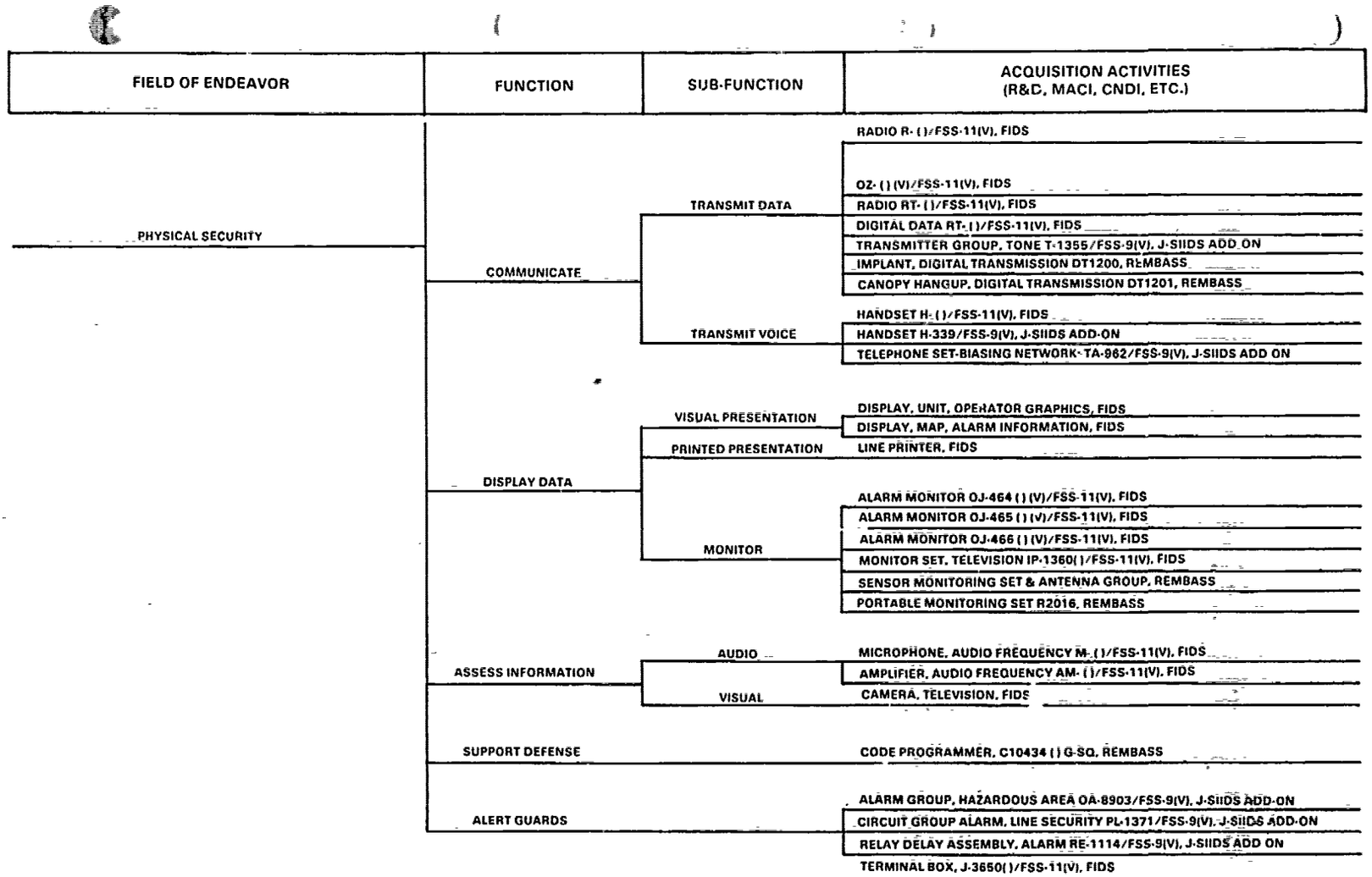


Figure VIII-3. Summary of Physical Security R&D Materiel Acquisition Activities (Continued)

change in temperature, etc. These non-intruder induced stimuli give rise to nuisance alarms which are indistinguishable from intruder induced alarms. For example, in an average size system which monitors 2,400 sensors in 100 secure zones, the average false alarm rate of each sensor is one every two months. This rate translates to one every thirty-six minutes in a system containing 2,400 sensors. The false alarm problem is magnified considerably for a large system. For example, in a large system which monitors 12,288 sensors in 256 secure zones the average false alarm rate for the whole system is approximately one every seven minutes. This creates an essentially continuous alarm status which greatly reduces the effectiveness of the overall system.

F. PHYSICAL SECURITY SCIENCE AND TECHNOLOGY PROGRAM

1. Science and Technology Base Program Products and Activities

The following S&T Base Program Products have been specifically instituted or planned to relieve the deficiency discussed in Section E. A graphic display illustrating the relationships and schedule is provided at Figure VII-4.

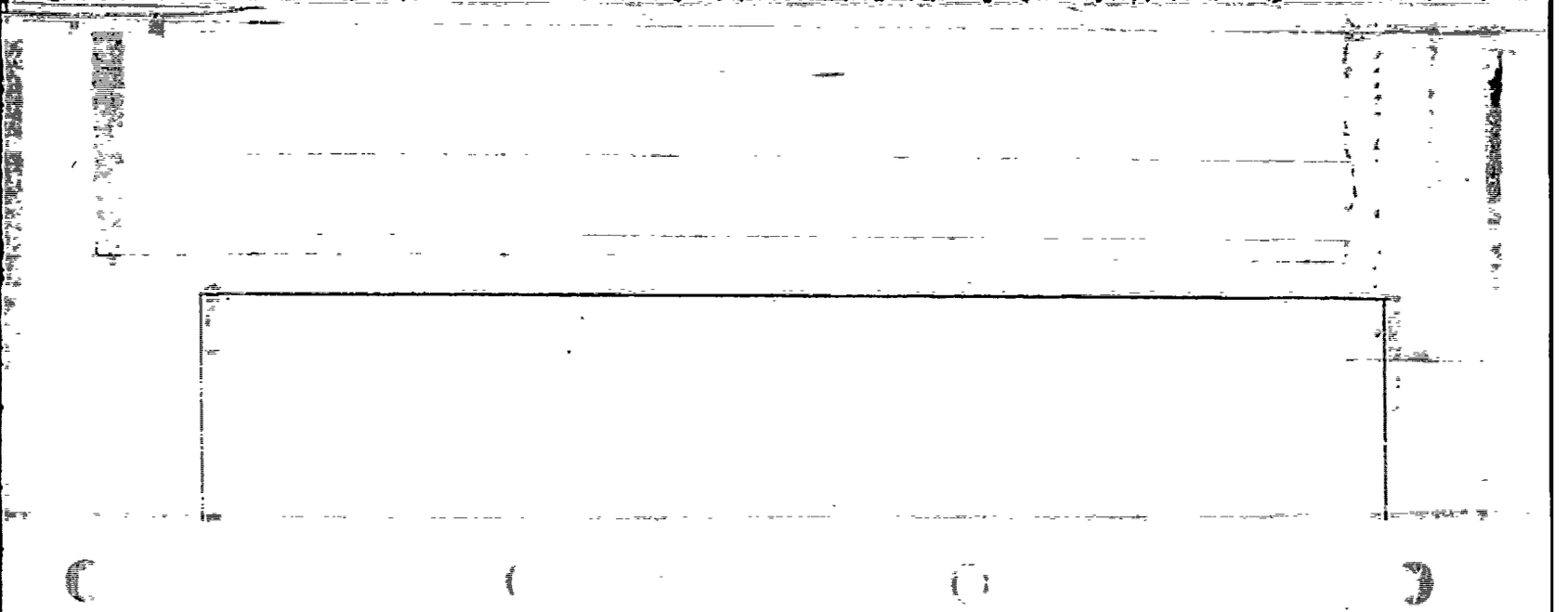
a. High Reliability Decision Logics

The data base of target signatures and statistical parameters extracted from target signatures that will be collected by the Data Acquisition system and processed by the Data Analysis System will be used to develop software algorithms and signal processing techniques, to distinguish intruder presence from natural phenomena. During FY85, site adapting sensor decision logics having high reliability of false or nuisance alarm rejection will be demonstrated. The chronology of specific activities in support of this product are:

(1) Analysis of Target Signature Data Base Requirements
(2) Development of Target Signature Architecture and Collection of Preliminary Data
(3) Target Signature Data Collection
(4) Demonstration of a Site Adapting Sensor
(5) Demonstration of a Feasibility of Detecting Presence of Intruder.

b. Intruder Presence Detection

The data base of target signatures and statistical parameters extracted from target signatures will be used to distinguish the phenomena associated with the presence of an intruder from the phenomena associated with the acts of an intruder. During FY87, the feasibility of detecting the presence of intruders rather than intruder acts will be demonstrated.



DEFICIENCY	TECHNOLOGY PRODUCTS	SCIENCE AND TECHNOLOGY BASE PROGRAM ACTIVITIES

	FY81		FY82		FY83		FY84	FY85	FY86	FY87
6.1										
6.2			200		185		228	*21	240	256
6.2a										

INABILITY TO DETECT, LOCATE, & NEUTRALIZE INTRUSION, ESPIONAGE, & SABOTAGE ATTEMPTS AGAINST FIXED FACILITIES AND SENSITIVE MATERIEL DURING TRANSIT OR WHILE STORED IN TEMPORARY SITES ON REAR AREA OF THE BATTLEFIELD WITH THE DESIRED DEGREE OF RELIABILITY WITHIN REASONABLE AND AVAILABLE MANPOWER RESOURCES

- HIGH RELIABILITY DECISION LOGISTICS
- INTRUDER PRESENCE DETECTION

TARGET SIGNATURE DATA BASE REQUIREMENTS ANALYSIS	TARGET SIGNATURE DATA BASE ARCHITECTURE DEV & PRELIM DATA COLLECTION	TARGET SIGNATURE DATA COLLECTION	DEMONSTRATE SITE ADAPTING SENSOR	DEMONSTRATE FEASIBILITY OF DETECTING PRESENCE OF INTRUDER

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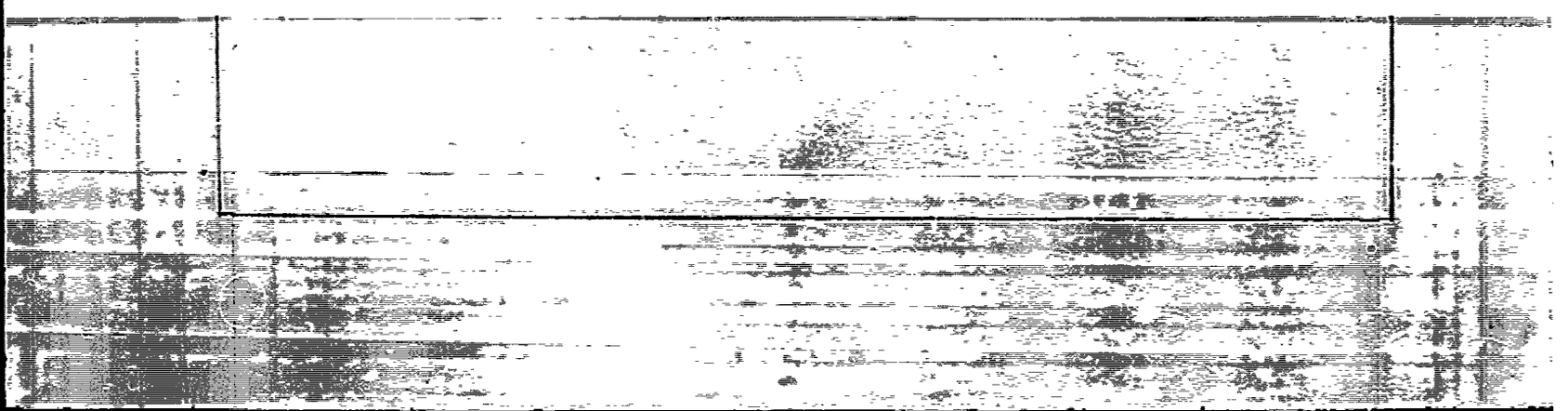
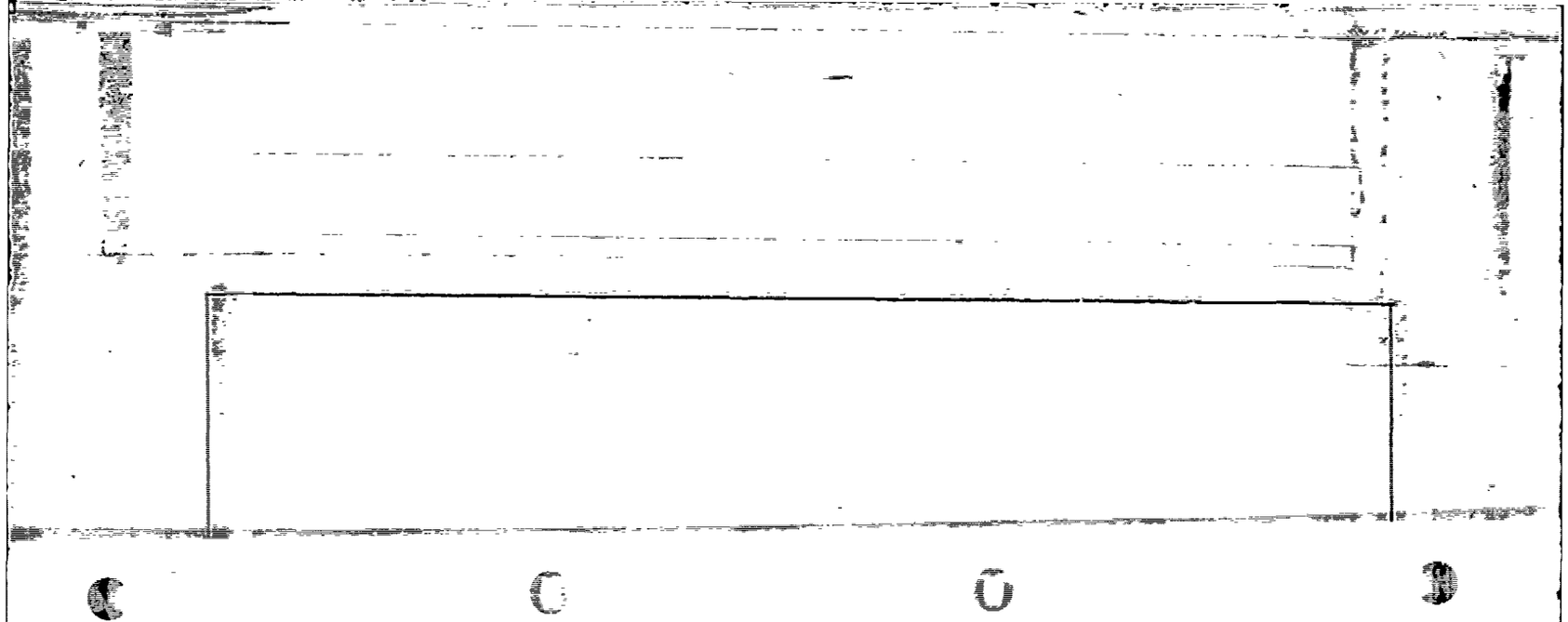
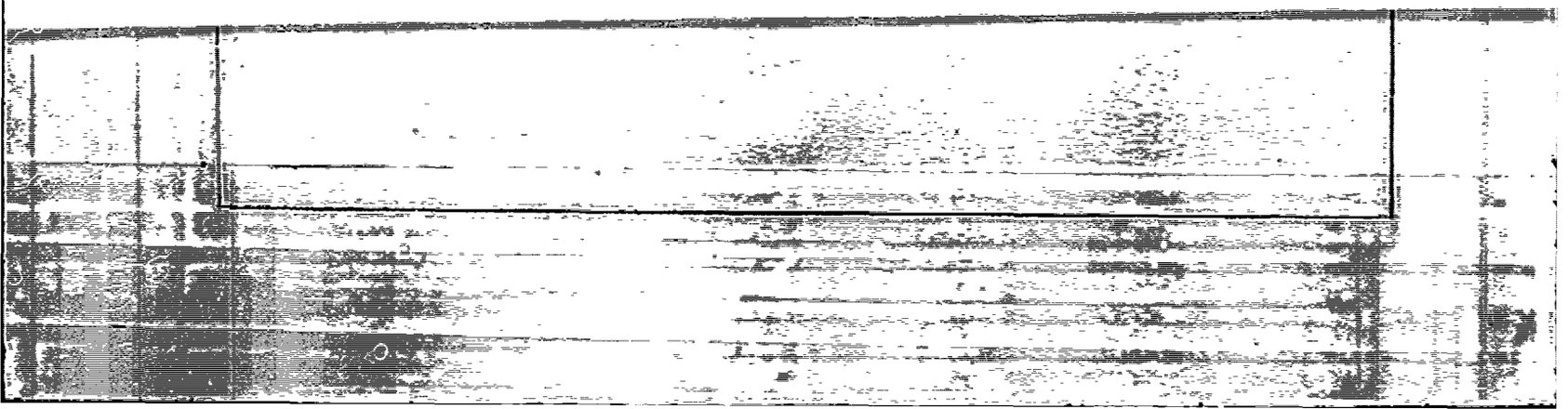
Figure VII-4. USAMERADCOM Physical Security Science and Technology Base Program Activities





CHAPTER VIII
TUNNEL DETECTION



CHAPTER VIII
TUNNEL DETECTION

A. MILITARY SIGNIFICANCE AND NEED

Tunnel detection prevents sudden large scale undetected underground infiltration of major high-value facilities and position areas. Such infiltration, if undetected, has a high probability of causing serious harm to the security of US forces and vital materiel.

B. FUNCTIONAL CHARACTERISTICS

Tunnel detection can be divided into two major functional areas. These are

1. Deep Passive (Completed) Tunnel Detection and Location

This function involves the detection of tunnels that are completed to the point of break through. It requires techniques to determine anomalies below the earth's surface which would indicate the presence of a tunnel.

2. Deep Active Tunnel Detection and Location

Active tunnels are those being constructed. The methods used to detect and locate active tunnels differ from those required for passive tunnels. These methods involve seismic/acoustic technology to pinpoint active tunneling operations.

C. CURRENT CAPABILITY

Although tunnel detection equipment has been developed for use in Vietnam and South Korea, no fully capable, reliable system exists for all areas. In particular, the Army has no current capability to detect passive (empty) tunnels at the required depths.

D. ACQUISITION ACTIVITIES

The systems in the field of Tunnel Detection under development by the US Army MERADCOM are described in detail in Volume VI (Field Fortifications and Counter Int.usion) of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. These developmental systems are listed in Figure VIII-1. Two of these systems which are presently under acquisition are shown in Figure VIII-2.

E. CURRENT CAPABILITY DEFICIENCIES

There are two major deficiences in the Army's current tunnel detection capability.

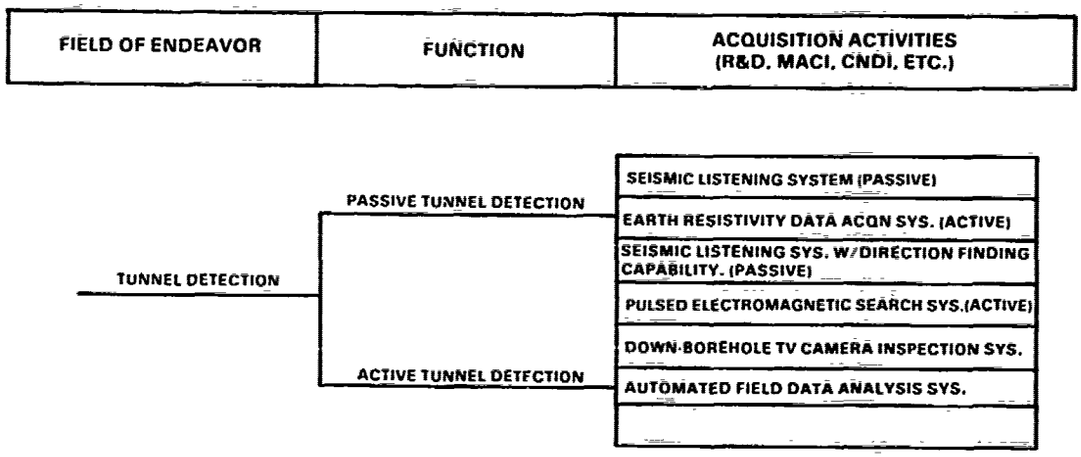
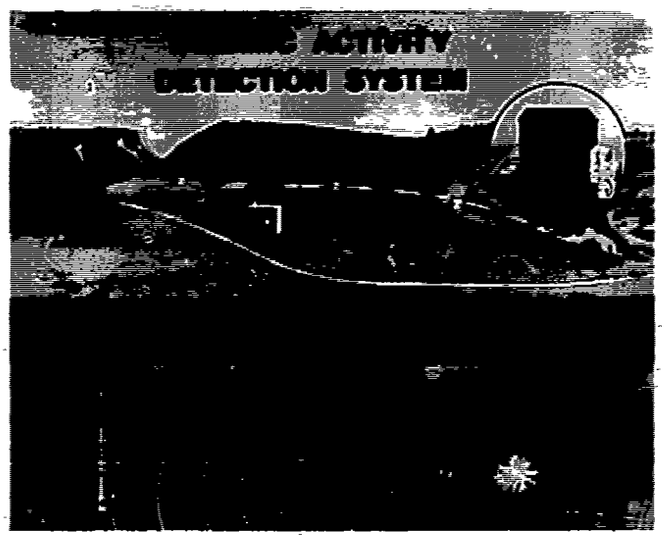


Figure VIII-1. Summary of Tunnel Detection R&D Materiel Acquisition Activities



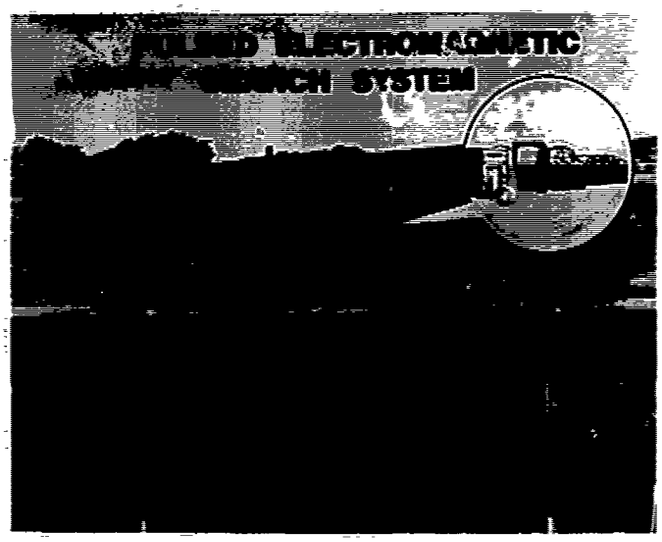


Figure VIII-2. Tunnel Detection Devices

1. There is Limited Capability to Detect and Locate Deep Passive Tunnels

Tunnels which are completed to the point of breakthrough (inactive) require different techniques for detection. Measurements of the subsurface take the form of determining the difference between the tunnel and the surrounding geology. Resistivity, electromagnetic/acoustic radar and cross borehole techniques are active systems which generate signals and measure anomalies caused by the presence of a tunnel. These systems have demonstrated short range or medium depth capability, but significant improvement is required. Data is required at different geological sites to determine quantitatively the parameters which are important to improved performance. Work is required to reduce the subjectivity of data analysis as well as to display data in an interpretable fashion.

2. There is an Inadequate Capability to Locate Deep (20 to 300 meters) Tunnel Construction with Sufficient Precision

Localized areas to be protected include DMZ sites, sensitive storage facilities and other critical sites. Existing systems have been designed to detect large targets (oil deposits, etc.) at great depths (hundreds of meters) or very small signals (wire pipes) at depths of only a few feet.

F. TUNNEL DETECTION SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

MERADCOM is engaged in a variety of R&D programs designed to overcome the tunnel detection deficiencies discussed in Section E.

Systems under development include seismic direction finding techniques, both from sensors in boreholes in competent rock and using surface emplaced triaxial sensors.

The increased resolution needed to accurately locate tunneling activity at depths from 20 to 300 meters requires higher frequency systems than those presently used for geophysical prospecting. Development of triaxial systems for use in boreholes is mandated to provide a point sensor to locate weak signal sources, which cannot be detected by all members of a long-based array of sensors measuring time difference of arrival. A short-based seismic survey is required to locate continuous seismic sources. The subsurface layering of the earth causes many reflections and refractions of seismic waves, and data must be collected and analyzed to determine the accuracy attainable for detecting activity from tunneling.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been

specifically instituted or planned to relieve the deficiencies cited. Figure VIII-3 illustrates graphically the relationships and schedule for these activities.

a. Passive Tunnel Detection & Localization

The products of this S&T effort will be demonstrations of the feasibility of the following concepts or systems to detect and locate passive (completed) tunnels.

1) Demonstrate Feasibility of Earth Resistivity Concept

Earth resistivity measurements have been used to detect anomalies at depths up to ten diameters by geophysical surveys. This was accomplished by interpreting first order changes in the resistivity as a function of position on the area being searched. Anomalous areas in earth resistivity measurements have been found at much greater depths by looking at second order changes in the resistivity data. The resistivities which have been used thus far have been based upon an algorithm which models the earth as a homogeneous half space with a numberable set of anomalies embedded in it. This analysis is highly subjective and demands a high level of training of the operator to produce a usable product. The product of this technology effort will be a processing algorithm based upon a multi-layered non-flat half space. This algorithm will be used to process data taken from a test site before and after a tunnel was driven beneath the test site, to show depths at which the tunnel can be detected and with what degree of accuracy it can be located. In addition, the analysis process will be automated to a greater extent to reduce the training requirements for the operator.

2) Demonstrate Feasibility of Magneto-Telluric Systems

This technology product will demonstrate the effect upon the propagation of an injected electromagnetic field of an anomaly such as a tunnel. Earth resistivity measurements address the effect upon a purely electric field while the magneto-telluric effort will look at both the magnetic field and the electric field. Successful completion of this product will provide a greater depth of penetration for the search system.

3) Demonstrate Feasibility of Activity Seismology System

4) Theoretical and Analytical Modeling Studies of New Concepts of Void Detection

This effort will yield a comprehensive model of a section of earth taking into consideration such things as mass removal, telluric currents from injected waves and from tunnel power lines, moisture content of porous rocks, water table changes, gas migration, etc. Predictions based upon this model will guide future refinements of techniques to improve accuracy of source locations and identification reliability.

b. Seismic/Acoustic Location System

The products of this effort will be designed to improve the capability to detect active tunneling operations at depths of 20-300 meters. This comprises the following S&T activities.

1) Demonstrate Feasibility of Seismic/ Acoustic Direction Finding

The construction and maintenance of hard rock tunnels introduce seismic signals into the ground/rock which are detectible at ranges dependent upon the amplitude of the injected signal, the efficiency of the coupling of that signal to the propogation medium, and the propagation characteristics of the medium. The characteristics of a particular site such as the presence of fault zones, highly weathered zones, etc., and the nature of the signal determine the means of inferring a probable source location and the accuracy of the location. Point sensors, such as triaxial geophone arrays, will be used to provide at least a vector from each detection event. The product of this technology effort will be to define the limits of accuracy of the calculated source location and to demonstrate that greater accuracies can be achieved through iterative solution/calibration cycles.

2) Demonstrate Feasibility of Wide Area Extended Arrays

The product of this technology effort will be the definition of the types of construction and maintenance tasks which will produce seismic signals of sufficient energy to be detected by at least 4 members of the sensor arrays, such that the solution of the source location can be obtained. The range of these signals will then determine the extent of such an array of sensors for broad front coverage.

3) Demonstrate Feasibility of Solid State Activity Recorder

A source of many false signals detected by the current generation of activity detectors is the moving parts and malfunctions of the mechanical tape recorder drives. The goal of this technology product will be to use high density, low power, solid state memory circuits to build a recording device with no mechanical noises associated with it to replace activity detector tape recorders.

4) Integration of Decision Logic in Direction Finding System

A major problem for an activity detection system is the storage of data in a remote sensing system. The use of higher frequency information makes possible better resolution of the source identification

problem and greater location resolution. In order to use these higher frequencies and still remain within the constraints of the data storage capacity, decisions must be made about the probable source of the detected wave before the data is stored. The goal of this effort will be to define those parameters which will lead to better source identification and incorporate these factors into a detector central circuit.

DEFICIENCIES	TECHNOLOGY PRODUCTS	SCIENCE AND TECHNOLOGY BASE PROGRAM ACTIVITIES

TUNNEL DETECTION

	FY81		FY82		FY83		FY84	FY85	FY86	FY87
6.1										
6.2	500		580		571		436	484		
6.3a										

- INABILITY TO DETECT/LOCATE PASSIVE TUNNELS → PASSIVE TUNNEL DETECTION SYSTEMS
  - DEMONSTRATE FEASIBILITY OF EARTH RESISTIVITY CONCEPT
  - DEMONSTRATE FEASIBILITY OF MAGNETO-TELLURICS SYSTEM
  - DEMONSTRATE FEASIBILITY OF ACTIVITY SEISMOLOGY SYSTEM
  - THEORETICAL, ANALYTICAL MODELING STUDIES OF NEW CONCEPTS OF VOID DETECTION
- INADEQUATE CAPABILITY DETECT/LOCATE ACTIVE TUNNEL OPERATIONS → SEISMIC/ACOUSTIC LOCATION SYSTEM
  - DEMO SEISMIC/ACOUSTIC DIRECT FINDING
  - DEMO FEAS OF WIDE AREA EXTENDED ARRAYS
  - DEMO SOLID STATE ACTIVITY RECORDER
  - INTEGRATE DECISION LOGIC IN DIRECTION FINDING SYSTEM

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Figure VIII-3. USAMERADCOM Tunnel Detection Science and Technology Base Program Activities

CHAPTER IX
TACTICAL SENSORS

CHAPTER IX
TACTICAL SENSORS

A. MILITARY SIGNIFICANCE AND NEED

Tactical sensors (classifiers) detect, locate and identify enemy forces and movement in a day-night all weather environment. These sensors complement and supplement other surveillance systems to provide the field army with a constant real-time early warning surveillance and target acquisition capability.

The information obtained from this comprehensive system enables US weapons to bring timely fire on enemy targets, and US forces to out-maneuver the enemy forces.

B. FUNCTIONAL CHARACTERISTICS

Tactical sensors can be divided into the following functional areas:

1. Surveillance for Small Units

This involves the detection, location and identification of forces of importance to Platoon size, or smaller, units. It encompasses sensors placed along critical avenues of approach (Route Surveillance) to detect enemy movement, and/or sensors emplaced around critical installations or assembly areas (Perimeter Surveillance) for security.

2. Surveillance for Large Units

This group of classifiers detects, locates and identifies forces of interest to Division and larger size units. It includes devices for route and perimeter surveillance, as described for small unit classifiers plus systems for surveillance of large areas such as division assembly areas.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability for remote tactical detection and classification of targets consists of the base line equipment shown in Figure IX-1. These items of equipment are:

1. Platoon Seismic Intrusion Detector (PSID)

The PSID is a small, low cost system that detects activity from seismic vibrations in the ground. It consists of four independent detectors linked by a low power VHF transmission system to a small receiver which emits audio tones to the monitoring operator.

2. Platoon Early Warning System (PEWS)

This system consists of several (128 possible area/ID codes) seismic/magnetic detectors and a receiver

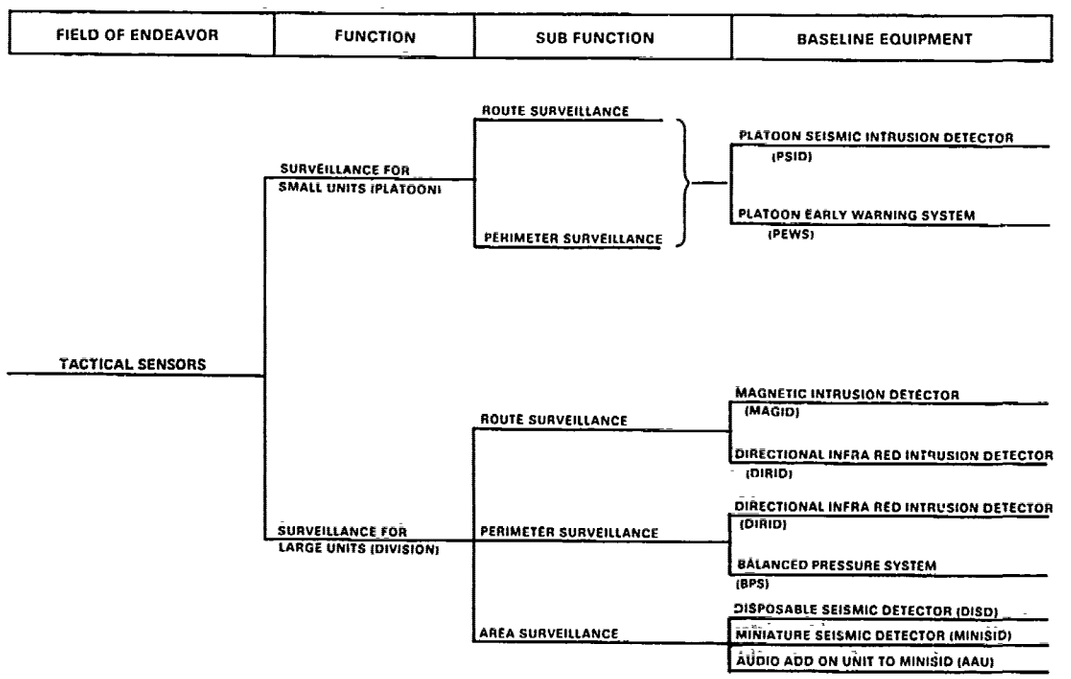


Figure IX-1. Baseline Equipment Summary for Tactical Sensors

which may be linked by either RF transmission or wire. Personnel or vehicle classification is provided by the detectors.

3. Magnetic Intrusion Detector (MAGID)

The MAGID is a passive magnetic sensor using one or two solenoid coils as detectors. This device is an ancillary detector to the Miniature Seismic Intrusion Detector III (MINISID III) which is part of the Phase III intrusion detection system developed by the Defense Special Projects Agency. The system uses an 18 bit frequency-shift key-modulated VHF radio link to the monitor console.

4. Directional Infrared Intrusion Detector (DIRID)

This device is a passive two angular window infrared disturbance detector, time-gated to reduce false alarms and provide target direction data. Alarms are reported by VHF radio link to the Phase III system monitor.

5. Balanced Pressure System (BPS)

The BPS consists of two fluid filled hoses emplaced parallel to each other underground in the area to be monitored. Targets are detected by pressure gradients in the ground over the hoses and a signal is transmitted to the monitor station by a wire link.

6. Disposable Seismic Intrusion Detector (DSID)

This is a small, low cost seismic detector linked to the Phase III system monitor.

7. Miniature Seismic Intrusion Detector III (MINISID III)

MINISID III combines the function of the DSID with a capability to accept ancillary detectors such as MAGID or the Audio Add-on Unit. It uses modular electronics and is connected to the Phase III link.

8. Audio Add-on Unit (AAU)

The AAU is an ancillary acoustic (remote listening) device which can be added to the MINISID III It transmits 20 seconds of audio signal thru the MINISID to the system monitor when the MINISID is triggered by seismic activity.

D. ACQUISITION ACTIVITIES

Figure IX-2 identifies R&D materiel acquisition activities. This is primarily focused on the Remotely Monitored Battle Area Surveillance System (REMBASS) which is a successor to the Phase III system described above. The major difference from the newer REMBASS system is its target classification capability and more elaborate monitoring system. The REMBASS sensor to monitor link is by way of a Frequency Shift Key (FSK) modulated VHF radio. Figure IX-3 shows several types of tactical sensors.

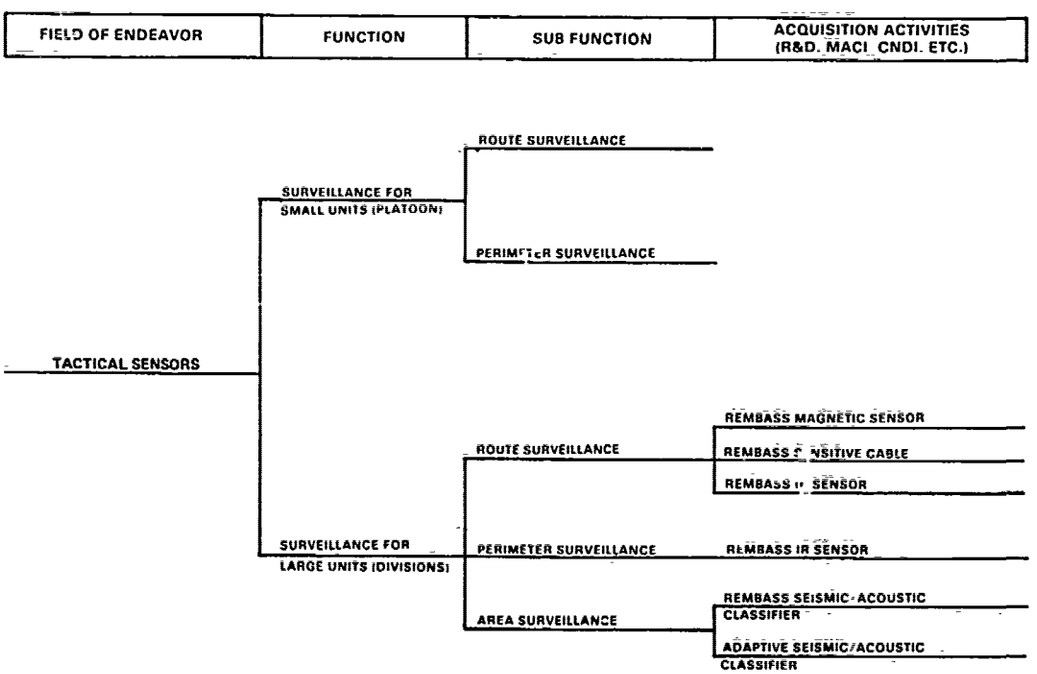


Figure IX-2. Summary of Acquisition Activities for Tactical Sensors

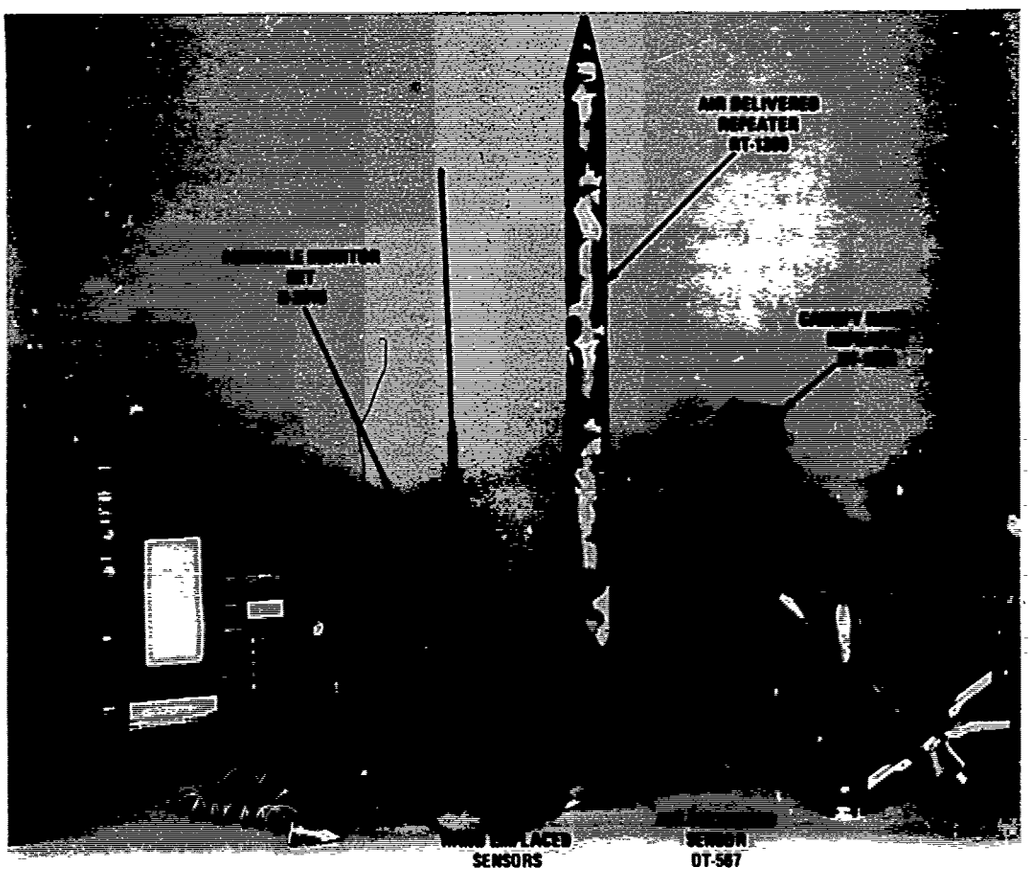
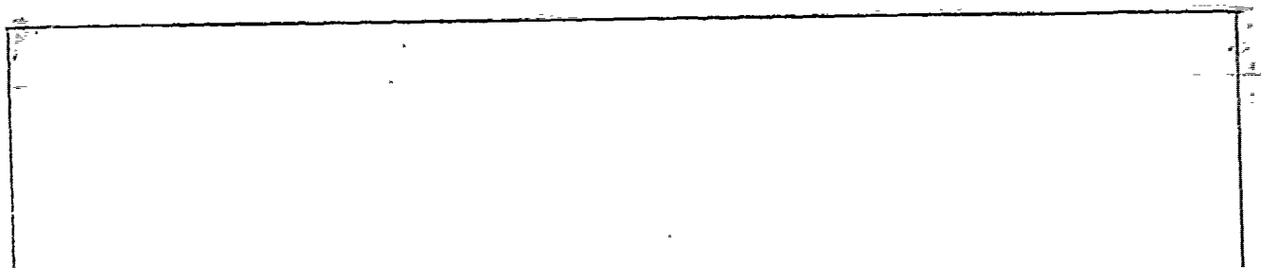


Figure IX-3. Tactical Sensors



E. CURRENT CAPABILITY DEFICIENCIES

There are two major deficiencies in the US Army's current capability to remotely locate and classify targets. These are:

(1) Inadequate capability to classify targets within a wide range of environments.

(2) Inadequate capability to accurately locate target/sensor positions.

F. SCIENCE AND TECHNOLOGY BASE PROGRAM FOR TACTICAL SENSORS

1. Discussion

Doctrine requires that a Commander know the composition of the threat force. For sensors to be successful in supplying this information, they must operate reliably in a wide range of environments and ambient noise.

Present classifiers operate using a low power analog processor to make a decision to initiate the digital classifier. Once this turn-on is made, a decision is forced by a comparison of the input against stored classification reference data. The performance is therefore limited by the applicability of the training data which is not changed depending on conditions.

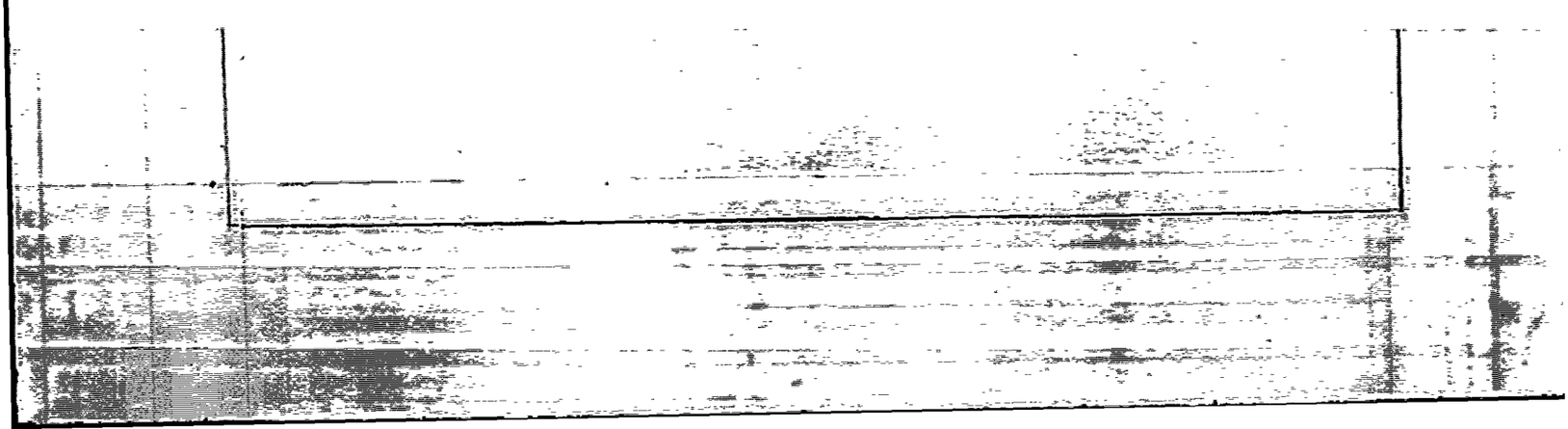
At least two possibilities exist for altering the reference data to alleviate the effects of varying conditions:

(1) Make reference data field updatable either through radio or attendant servicing.

(2) Make the reference base modifiable by sensor self-measurements of environmental conditions taken from the "normal" background.

The problem of identifying vehicles by type is substantially different from that of classifying vehicles into broad categories and the former is more feasible. This is true because the signature characteristics of targets within a broad class are more diverse than those of an individual type and the decision boundaries are correspondingly more vague and have a greater tendency to overlap. While the hardware for both types of classifiers may be similar or even identical, the decision process and training data would be different.

The most efficient way to evaluate the performance difference between approaches to the classification problem would be to model the existing algorithm and alternative algorithms on a suitable processor and make comparison runs against recorded target signatures.



2. Science and Technology Base Program Products and Activities

In response to the deficiencies listed in Par. E above, USAMERADCOM has initiated a variety of S&T Base Program Activities designed to overcome these problems. Figure IX-4 illustrates the relationship between the specific deficiencies and the technology products and activities, along with the planned schedule and level of funding for these activities. The following summarizes the work to be done for each S&T Base Program Activity.

a. Demonstration of a Seismic/Acoustic Target Classifier

The demonstration of feasibility of a reliable seismic/acoustic target classification sensor for personnel, wheeled and tracked vehicles, helicopters and fixed wing aircraft will be based on the development of improved classification algorithms designed to minimize the problems of classification over varying target ranges and speeds. This development will require the assembly of a suitable signature and background noise data base incorporating as much existing data as practicable. The resulting classifier will probably require added information storage and processing capacity compared to existing classifiers and may be site-oriented.

b. Demonstration of a Cultural/Environmental Site Adaptable Classification Sensor

Performance characteristics will be evaluated for two types of site adaptable classifiers. One type will be manually adaptable by selection of classification reference data on a site specific basis prior to deployment. A second type will use a site adaptive classification algorithm which will periodically sample the ambient signal conditions and modify the decision processing to compensate for change. These adjustments will primarily affect the characterization of the noise but limited inferences will be made concerning target signal characteristics changes; for example, a long term spectral upshift in seismic background noise would imply a similar change in target signature due to transmission medium characteristic shift. A three-way classification performance comparison will be made against the data base among the original algorithm, the original algorithm with site dependent classification reference data, and the adaptive algorithm. This comparision will be the basis for implementing the selected classification algorithm in final hardware form.

c. Demonstrate Feasibility of Identifying Targets Within a Class

The ability to identify individual target types will be based on the use of target signature reference data for the specific type target to be classified as

opposed to references of broad class representation as has been previously done. This will result in better correlations for the targets included, but will force a trade-off evaluation of the number of target types classifiable versus target reference storage capacity and longer processing time. Trade-offs in those areas will be evaluated against the data base. The selected compromise will be implemented in hardware prototype for field testing.

d. Demonstrate a 25 Meter Sensor Position Location System

The sensor location function must be accomplished without adding substantial cost to the sensor and without compromising the other operational attributes of the sensor. Radio direction finding on the sensor reporting transmission is believed feasible, but is untested. Several other possible means of sensor location will be investigated including existing navigation systems and satellite location. Cost and operational trade-offs will be evaluated and the best technology selected.

Prototype sensor location systems will be built and tested in a variety of environments.

e. Demonstrate Target Location From a Known Sensor

Target location relative to the sensor over relatively long ranges has previously been unsuccessfully attempted using short baseline (1 meter) array acoustic location techniques and analog signal processing. This technique will be re-evaluated using updated digital signal processing. Improvement possible due to the more favorable geometric properties of longer baseline arrays will also be evaluated. These evaluations will be done using prototype systems in a variety environments.

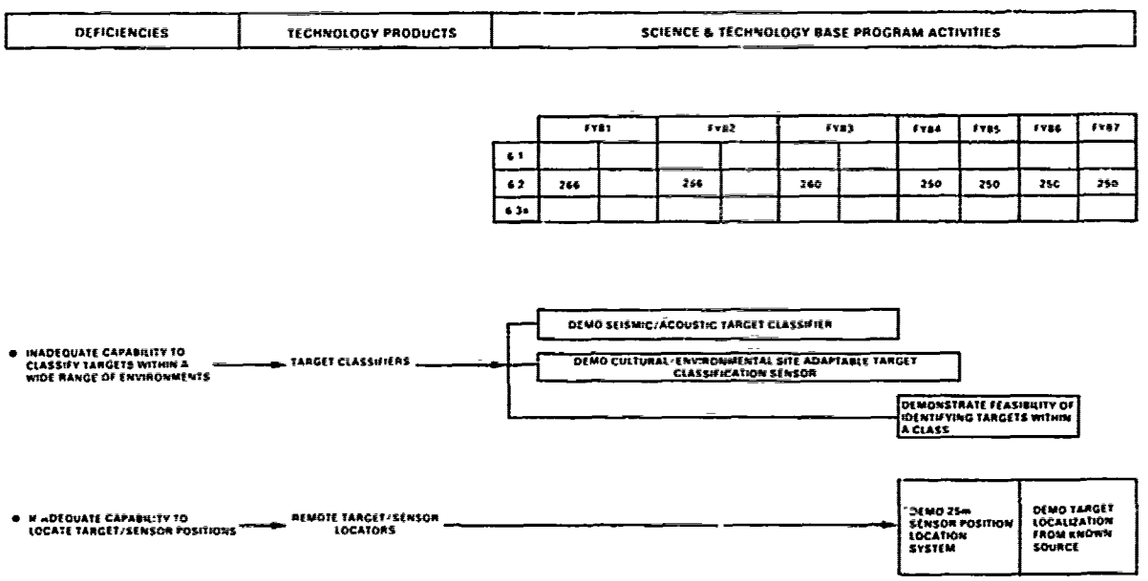


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Figure IX-4. USAMERADCOM Tactical Sensors Science and Technology Base Program Activities

CHAPTER X
ELECTRIC POWER

CHAPTER X

ELECTRIC POWER

A. MILITARY SIGNIFICANCE AND NEED

Mobile Electric Power Plants are essential to the operation of advanced weapon and command, control, communication and intelligence (C^3I) systems. In addition, these plants are needed in the field for functional test of weapon system and support equipment to insure the high state of readiness demanded by Army combat forces.

B. FUNCTIONAL CHARACTERISTICS

The field of endeavor of electric power can be divided into five major functional areas.

1. Generate Power

This function involves the generation of electric power by various methods through electrochemical and solar means, and the use of electromechanical devices (generator sets and power units/power plants). The function includes the prime movers which power the generating equipment. Electrochemical power plants include methanol-fueled fuel cells utilized in silent, lightweight electric energy plants now under development. Solar power plants include photovoltaic energy production devices which convert solar energy directly into electrical power.

2. Energy Storage

This function includes various energy storage devices now under development for future applications. Included are batteries for electrochemical storage, flywheels for electromechanical storage, and thermal energy storage devices.

3. Distribute Power

This function involves the processes of power conversion through transformers; power transmission through conductors, cables and fibers; power control through solid state switches; load management, and junction distribution.

4. Condition Power

This function involves the use of inverters, converters and various other power conditioning devices to enable the field Army to operate tactical equipment from indigenous power supplies, generator sets or commercial utilities, of foreign or US manufacture where frequency and/or voltage are incompatible or power quality is not adequate for the using element.

5. Use Power

This function involves the various tactical and non-tactical uses of electric power in the form of lighting

applicatic·s, electric motors which are an integral part of fielded equipment, battery charging devices, and load testing equipment.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet its electric power requirements is represented by the baseline equipment shown in Figure X-1. Descriptions of each of these items are presented in Volume III of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing electric power capabilities are summarized below.

The primary capability for generating power consists of a range of generator sets, power units and power plants which utilize gasoline and diesel powered prime movers, and gas turbine engines. Generator sets are configured to provide electric power ranging in output from 500 watts to 750 kilowatts. Twenty-eight volts DC, or 50, 60 and 400Hz AC may be produced according to the design of the particular set. All voltage and phase outputs are not available in the full range of capacity. The sets produce 60Hz and 400Hz precise power (TP designated) or 60Hz utility power (TU designated) to satisfy requirements of different applications. The Department of Defense family of mobile electric power generating sources, which includes Army generator sets, are portable (skid mounted) or trailer mounted depending on the size of the set. Power units and power plants consist of combinations of generator sets mounted on trailers to form self-contained, mobile electric power sources for various applications. Generator sets, power units and power plants use standardized components appropriate to the capacity and characteristic output of the power source. Since 1967 when a DOD Project Manager was created for Mobile Electric Power, the establishment of a single focal point for all generator sets has greatly reduced the proliferation of mobile electric generating equipment and has simplified developmental and logistical problems previously experienced.

The Army's current capability in energy storage is limited to wet and dry cell type batteries which are used for standby power in operational installations and to power certain types of highly portable equipment. Limited storage capacity in existing batteries has prevented certain types of technology development and has imposed severe constraints on some tactical equipment. This is a functional requirement that is receiving greater emphasis on development.

Power conditioning and power distribution capability is confined generally to providing power of the required specification (voltages, phases, frequency, quality) to support

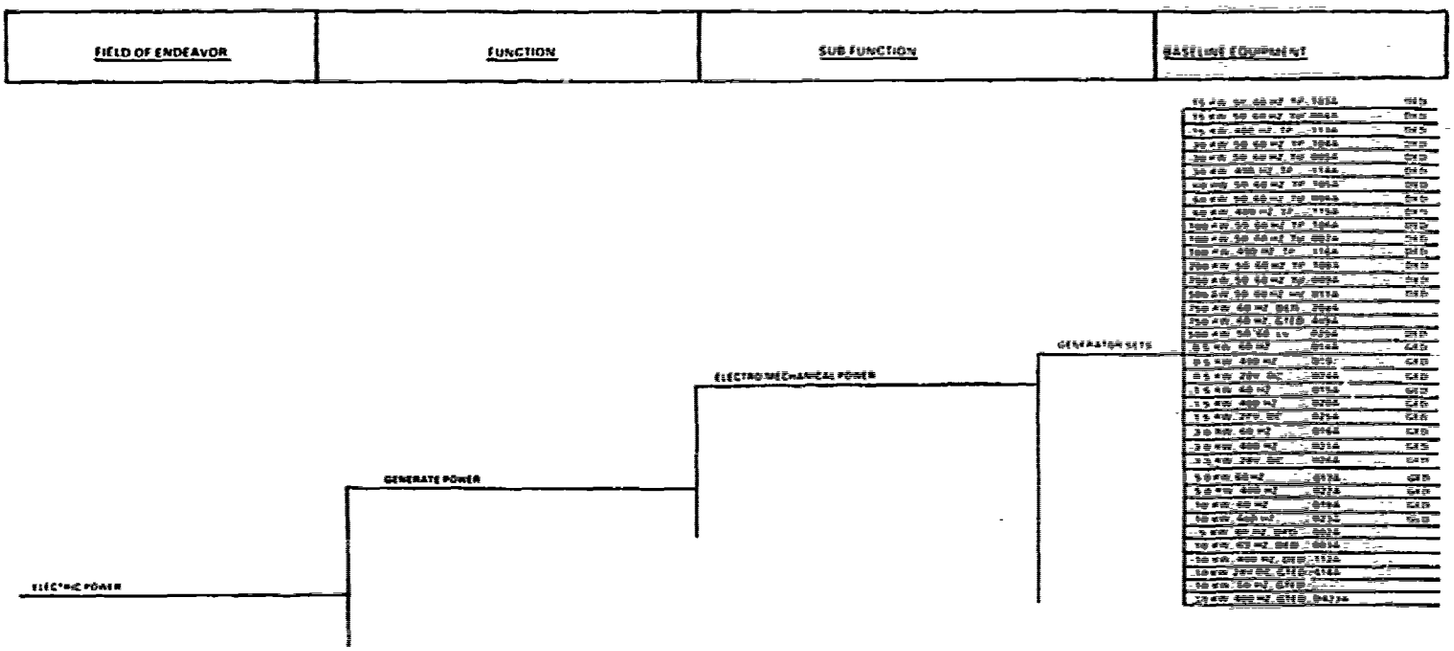

Figure X-1. Baseline Equipment Summary for Electric Power

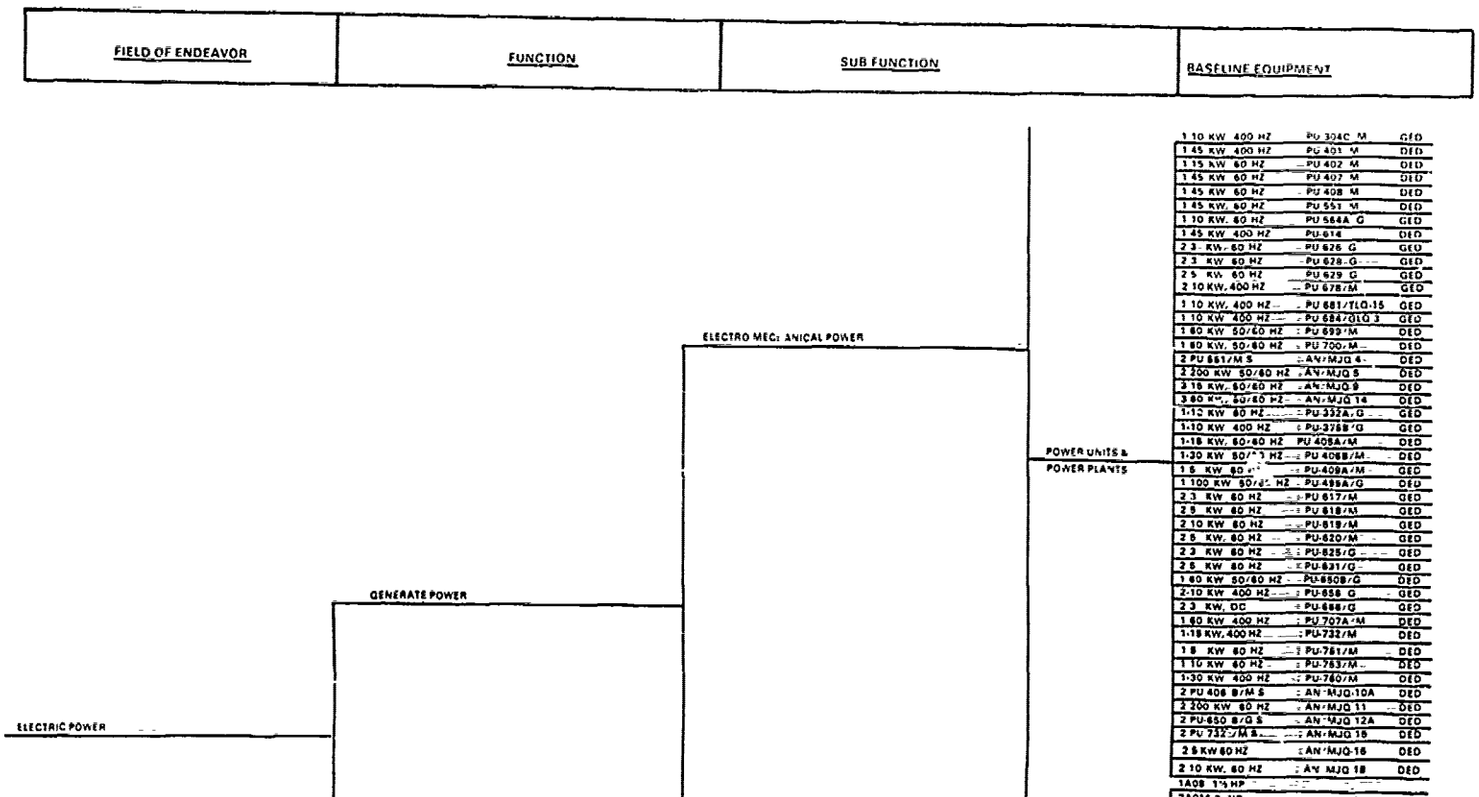

Figure X-1. Baseline Equipment Summary for Electric Power (Continued)

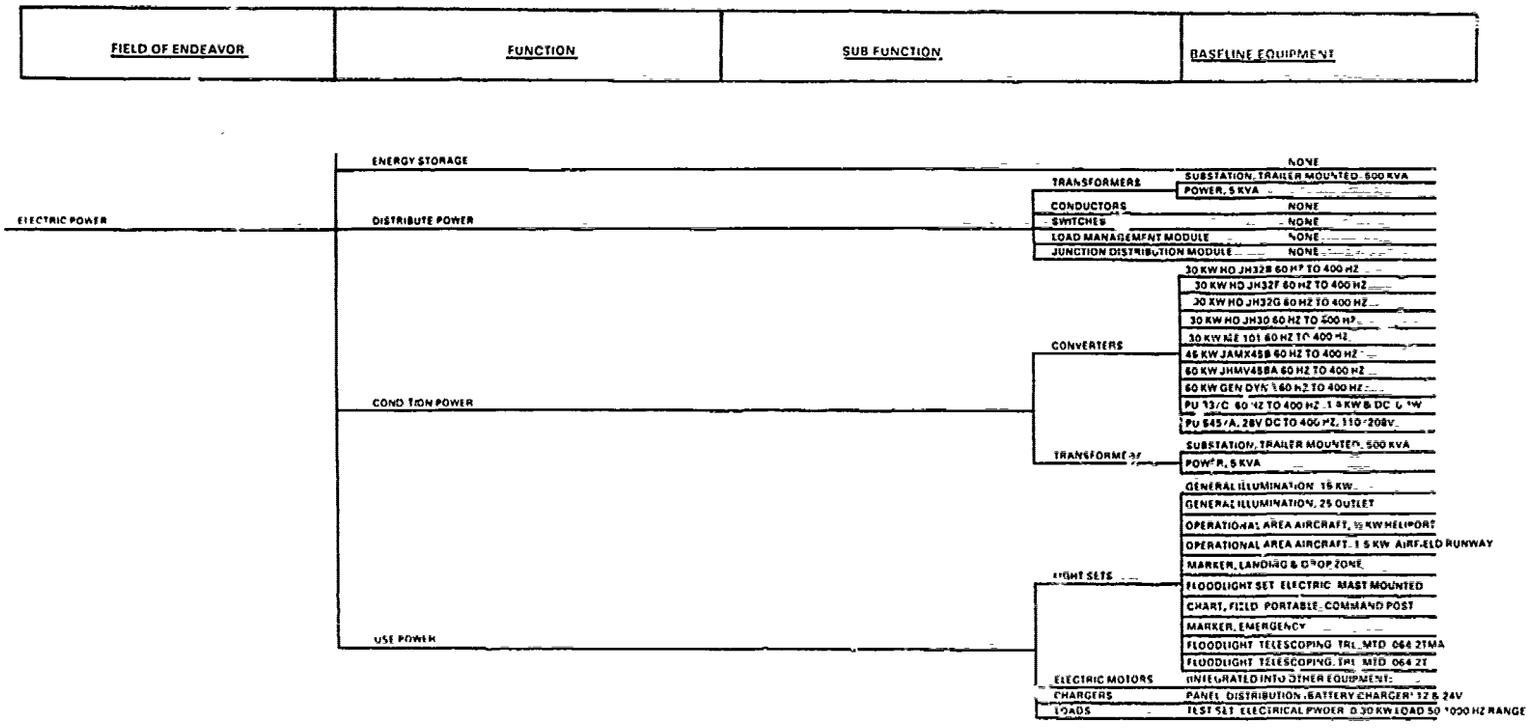

Figure X-1. Baseline Equipment Summary for Electric Power (Continued)

using units in the field. Converters, transformers, junction boxes, switches, cables, conductors and insulators are largely of commercial design.

D. ACQUISITION ACTIVITIES

Current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs are shown in Figure X-2. At present these are focused on a new 10 KW gas turbine engine driven generator set having a multifuel capability; silent lightweight electric energy plants (SLEEP) in 1.5, 3.0 and 5.0 KW output capacity models; special purpose diesel and gas turbine engine driven generator sets for a variety of DoD customers (e.g., Project Managers); and a solar power unit being developed for the US Marine Corps.

The 10 KW GTED generator set will be capable of delivering 28 volts DC for aircraft starting.

The SLEEP plants are fueled by an aqueous solution of methyl alchohol and are powered by a fuel cell. These will be lightweight, compact, silent plants for operating communications equipment, command posts, visual and IR illumination devices, ground surveillance radars and battery chargers. The use of methanol as a fuel offers the benefit of deriving fuel from renewable non-petroleum sources.

The solar power unit will provide a field power source to partially operate manpack radios and to charge batteries wherever sufficient light exists to efficiently utilize the sun's energy.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current electric power capability and ongoing acquisition activities versus current needs has revealed the following five major deficiencies:

1. Current Technology Cannot Support High Priority Special Purpose Generator Requirements

High priority weapons systems have historically posed unique and difficult electrical power requirements in terms of mobility (weight, volume, packaging), reliability, or quality and type of power required. Redstone, Pershing, Hawk, Patriot, M1, Firefinder, Sergeant, and Mobile HiPar are examples of applications where special requirements were met with specially developed equipment. The major thrusts in special power requirements are typically higher power density, a faster response, higher reliability, and efficiency coupled with reduced signatures and affordability. Special power source development is an area that is deficient in Technology Base continuity because the needs are not forecast or anticipated in advance.

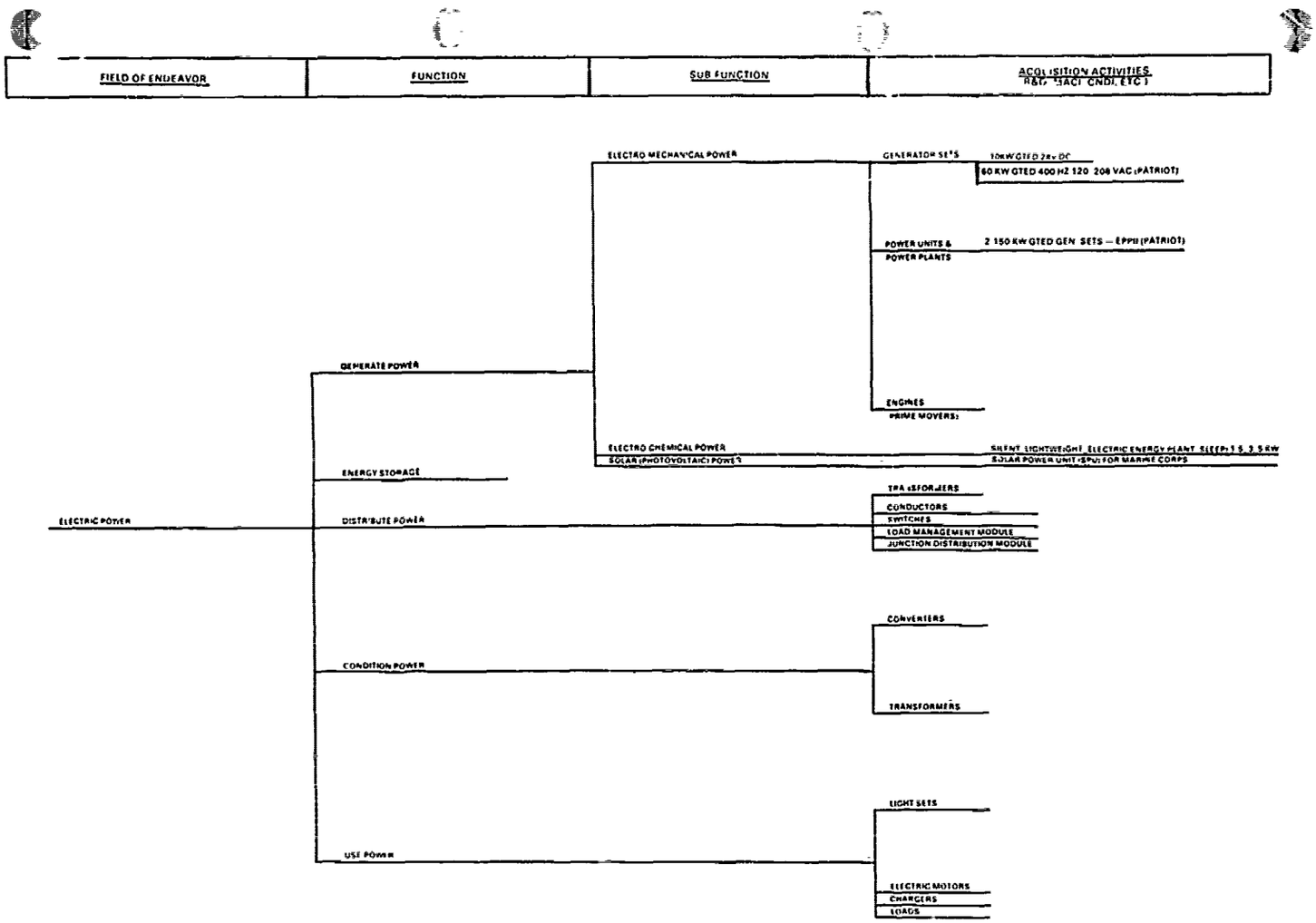

Figure X-2. Summary of Electric Power R&D Materiel Acquisition Activities

2. Lack of Capability to Operate on Alternate/ Emergency Fuels

Future power generating equipment must effectively use a wide variety of synthetic or alternate fuels. Technology and hardware for using fuels from renewable energy resources, wherever feasible, does not exist and must be developed.

3. Inadequate RAM-D Characteristics and Fuel Efficiency

A minimum of efficiency improvement of 15 percent has been mandated for all mobility fuel-consuming equipment including electric power generation and distribution The DOD combat forces are dependent on electrical power produced by mobile power sources. The magnitude of this dependency is enormous and encompasses battery charging, lighting, environmental control, communications, surveillance, fire control, and maintenance. Consequently, the logistic supportability of electrical power generators is critical to the operational effectiveness and readiness of most TOE units. The complexity of logistic supportability is directly related to fuel availability, fuel consumption, RAM-D characteristics, degree of standardization, NATO interoperability, training requirements and personnel capabilities. Affordability is the cloud which covers all of these elements. In simplest terms, the deficiency is that electrical power generation equipment has severe logistic burdens that detract from mission effectiveness. There is a definite need to reduce consumption of fuel and parts, to insure synfuel/multifuel capability, to increase standardization and interoperability, and to reduce personnel requirements, while improving affordability.

4. Non-availability of Mobile Power Sources for Directed Energy Weapons

Beam weapon systems will require large amounts of electrical power supplied in high energy pulses. Tactical power sources, suitable for this type of service, do not exist and must be developed. To capture the maximum potential of future beam weapon systems, tactical equipment which can provide high energy pulsed electrical power must be developed. Without this new power source technology, most of the missions being considered for electrically driven beam weapons cannot be realized.

5. Inadequate Power Conditioning and Distribution Systems

The Army's capability of supplying electric power to tactical users is limited by a lack of power conditioning and distribution equipment. The present capability requires that a tactical generator set, specific to the load system, be colocated with each load and be compatible in voltage, frequency and quality of power. As a consequence, logistic support of fuel supply and maintenance for the power source must be provided to the user site. This situation results

from a lack of power conditioning equipment which would convert available power to user requirements and from lack of general purpose distribution systems which would supply power to a number of users from a single central source. This source would be a larger unit having relatively high RAM-D characteristics, located to enhance logistics support, or an indigeneous generator set or utility supply. In addition to its impact on logistics, correction of the present deficiency would reduce noise and extend the life of small tactical generators by reducing reliance on them to those occasions when no other source was available. Moreover, the existing problem of not being able to operate US forces equipment with equipment of other nations due to differences in voltage and frequency, must be eliminated. The lightweight, ruggedized, tactical cable distribution systems which can be rapidly deployed, retrieved, and redeployed in a hostile environment are not presently available. Power conditioners which are compact, mobile, and rugged do not exist.

F. ELECTRIC POWER SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies cited above, a variety of S&T efforts have been initiated. These initiatives show promise for correcting deficiencies and for advancing the capabilities of Military electric power.

Several major thrusts have been identified as part of the MERADCOM FY 82-86 S&T Base. These are as follows:

a. Electrochemical/Fuel Cells

This thrust encompasses establishing the science and technology base necessary for the development of direct oxidation and advanced electrolyte fuel cell systems which can utilize logistically available fuels either by directly oxidizing them or first transforming them into a hydrogen-rich fuel. More specifically, this involves developing an understanding of the interactions and relationships of catalysts, electrolyte and reaction kinetics and mechanisms of various fuels in fuel cells, determining operational parameters of fuel cell systems and establishing fuel conditioning techniques for logistic and future fuels.

This thrust involves efforts that range from medium risk to relatively high risk. Direct oxidation fuel cell systems which offer the greatest payoff represent a high risk area of effort. There is very little technology available which is applicable to this area. Efforts on combining advanced electrolyte cell systems with fuel conditioning are considered to be medium risk. Risk arises in adapting proven technologies to satisfy military requirements.

The fuel cell power plants resulting from this thrust will be more efficient, longer-lived, more

reliable, lower in weight, smaller in volume and lower in costs than state-of-the-art fuel cell systems and will improve in almost all of these factors over present engine generator sets.

b. Power Conditioning/Control

This thrust encompasses conditioning of electric power along with associated control functions to provide power of the required specification (voltages, phases, frequency, quality) to support using units in the field. The effort addresses the requirements of the Science and Technology Objective on Power, which emphasizes standardized modules, instantaneous power, reliability, portability, multipurpose capability and development of power conditioners to allow utilization of available local power. The approach is to develop and utilize standardized modules and common controls to achieve enhanced RAM, power density, and lower cost in military power conditioners. Technologies involved include microprocessors, modular power functions and advanced switching elements and materials. The risks associated with application of microprocessor techniques and modular power functions are low while the risks in developing and applying new switching elements is moderate. The pay offs in enhanced availability of power, increased mobility and higher RAM would contribute significantly to improved power conditioning.

c. Transmission and Distribution

This thrust encompasses transmission and distribution of electric power from the generating equipment to the user in tactical field units. This effort also addresses the Science and Technology Objective on Power, which emphasized standardized modules, instantaneous power, reliability, portability, reduction of fuel consumption, multipurpose capability and use of local power for requirements up to 30 KW. The approach is to develop standardized modular distribution systems which offer rapid deployment and redeployment capability. Such systems are not presently available.

A number of technology areas are involved, including development of new lightweight, high conductivity materials, application of lightweight insulation materials and development of rugged standardized modules to meet system requirements. The risk associated with development of standardized modules and lightweight insulation is relatively low while the risk in developing a new lightweight conductor is moderately high. The pay off is in increased mobility and better availability of electric power in the field.

The Army Energy Efficient Mobility Systems Research Program also contributes to the Electric Power S&T Base Program in several ways. The purpose of the program is

to develop a strong technology base integrating new energy efficient materials and concepts into mobility related research. The major areas of technical opportunity in energy efficient systems technology are for power train improvements in the near and long terms. In the near-to-mid-term, specific materials and processes advances can be incorporated in programmed engines to gain improved performance. New engine concepts and engine material development offer considerable advantages to system design due to reduced weight, volume, cooling, and fuel requirements. Some of the opportunities for advanced technology improvements are:

(1) Ceramic turbine and recuperator components for turbine engine higher temperature/efficiency operation
(2) Thermal and noise barriers and coatings
(3) Cast radial flow compressors/turbines offering low cost and high efficiency
(4) Self-cleaning, minimum maintenance air filtration systems
(5) Micro-processor controls for fuel sensing, injection, turbo-charging wide fuel tolerance adjustment and transmission shift optimization
(6) Micro-processor controls for vehicle electrical, diagnostic, prognostic and recording systems
(7) Electric drive vehicle systems.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in paragraph E. Figure X-3 illustrates the relationship and schedules of the various activities.

a. Low Logistics Burden

The products of this S&T effort will contribute to improved supportability and RAM characteristics which will result in a higher degree of operational readiness with reduced maintenance and replacement costs. Specific activities are:

1) Fuel Cell Systems

The use of impure methanol and synthetic fuels in fuel cells will reduce the support of power generating systems in this process. The objective of the research is to evaluate the feasibility of a direct oxidation fuel cell using logistic fuels. The absorption and oxidation characteristics of low molecular weight alcohols and hydrocarbons will be studied on noble and non-noble metal catalysts. In FY81 the investigation of the reactions of long-chain hydrocarbons on platinum will be initiated. From FY82-FY86, the direct oxidation of logistic fuels and long-chain hydrocarbons will continue to establish fuel cell

performance with noble, non-noble and composite electrodes. Due to lack of specific information in this area these studies are considered high risk. The product of this project will result in the acceleration of the evaluation of direct oxidation-hydrocarbon anodes with impure methanol and synthetic fuels.

Another project will lead to the fielding of a fuel cell system that will reduce the fuel logistics burden presently experienced with power generating systems. The product of this project will be an accelerated feasibility demonstration and exploratory development of a thermally integrated methanol/air fuel cell.

A third project will consist of the development of efficient, photo electric generation of hydrogen and new storage techniques to reduce the logistics burden of fuel for fuel cell generators. An accelerated feasibility demonstration of an advanced hydrogen generation and storage alternative will be the product.

2) High Durability Efficient Components

High temperature heat exchanger systems and regenerators/recuperators for gas turbines and heater heads for Stirling engines combined with high temperature component designs featuring ceramic and or advanced powder metallurgy materials and processes; will yield optimum combination of multifuel/alternative fuel capability and high efficiency, low fuel consumption power plants. Research is proposed based on higher efficiency simple and regenerated cycle gas turbine power with fuel consumption reduced 1/3 to 1/2 of present levels. The combustion system will be optimized for multifuel/alternative fuel operation and a demonstration of improved turbine combustion will be the product of the research.

Further improvement in turbine engine operation will result from improved fuel controls. This research project will develop a fast response, reliable engine generator set control system that provides the required quality of electrical power in generator set application over the military environment. Adaptive features that permit monitoring and assessing engine wear with resultant adjustment of appropriate engine systems to extend engine life will be included. The research product will be a demonstration of improved turbine fuel controls.

Another project will involve more efficient and economical storage of electrical energy to effectively reduce the logistics burden on electric power generation systems. The technology product will be an advanced feasibility demonstration of an iron Reduction Oxidation (REDOX) secondary cell.

To improve the potential of using hybrid electric power sources for vehicular propulsion a research

project is proposed to deal with this technology. The objective of this effort is to develop hybrid electric power sources (fuel cell/battery) for use in Army materials handling equipment to enhance operating capability in enclosed areas. In addition, these power sources would be used to increase the range of electric vehicles before recharging of batteries and refueling is required, thereby making them competitive with conventional vehicles for many Army applications. In the time frame from FY80 to FY86, the charge/discharge profiles of traction batteries will be established from field tests and their applicability for use in hybrid systems evaluated; a hybrid power source consisting of a methanol reformer, fuel cell, and suitable batteries will be assembled and bench tested to load profiles of Army material handling equipment; integration and development of suitable controls will be carried out; and feasibility for other types of vehicles will be determined. Advances in fuel cell and battery technology will be incorporated in these studies as they occur. Concurrent programs in the fuel cell and battery areas provide sufficient information to make this a medium risk effort. The products of this research will be a demonstration of an improved bi-pole battery and a demonstration of a hybrid electric power source for vehicular propulsion.

3) Alternate Fuels

Solar cell fabrication processes currently being developed by the photovoltaic industry, such as unique doping and growth techniques, have produced photovoltaic cells, such as cascaded cells and silicon ribbon cells, in laboratory samples. The dendritic web process, the edge film growth process, and other ribbon growth techniques will be sufficiently advanced for application to tactical military solar panels. These panels will be used in solar power supplies ranging from manpack systems to small mobile electric power units. Such power supplies will support battery charging, communication and other requirements in the field and will augment fielded engine generator sets in many instances. This effort will explore encapsulation techniques and materials for panels using the newest photovoltaic cell designs available. Emphasis will be on making the panels suitable for the wide range of military environments. The product of this research will be a demonstration of a tactical solar P/V cell power unit.

b. Power Conditioning and Distribution Systems

1) Power Conditioners

Microprocessor technology is being explored for application to all areas of control required in power conditioners, including BIT and BITE. It is anticipated that software programmability and flexibility will

allow development of common, modular controls for families or classes of equipment resulting in enhanced RAM and reduced cost. Lightweight, reliable power conditioning equipment will permit the Army to supply power from available sources to meet the varied requirements of equipment in the field. Microprocessor technology offers modularity and commonality of control functions and contributes to high RAM characteristics of the equipment. The research effort is to demonstrate the advantages of these techniques by development of a control system for use with existing prototype power conditioners. Information gained from this application will be used for integration of the technology into the power conditioner family. Additional effort integrates microprocessor technology into the power conditioning program through development of a prototype designed to take full advantage of the available technology. The prototype builds on information gained from the previous step of microprocessor controller design and evaluation. The unit is expected to demonstrate the potential cost savings, lightweight, and high RAM associated with this technology. Highly reliable, lightweight power conditioners will permit supply of power to a variety of users from available sources. The risk associated with application of microprocessor technology to military power conditioners is relatively low. The pay off in modularization and increased RAM supports power conditioner requirements. The technology product/output will be the development of an experimental prototype microprocessor-based power conditioner.

A significant step in establishing the feasibility of modular integrated power switch (IPS) technology for military power conditioners is the 30 KW experimental prototype. Present research consists of the evaluation of a 15 KW prototype with the same techniques being extended to the 30 KW item. Modularization techniques and modular assemblies are emphasized. Multiple ratings are achieved through concatenation and interconnection. The next step in meeting the needs of supplying electric power to the variety of units and equipment in the field is the development of a 60 KW prototype so that a range of ratings is available for use with militar power conditioners. These power conditioners will permit conversion of power from available sources to meet specific user requirements, eliminating one of the problems in supplying electric power to tactical units. Power conditioners based on the IPS, a self-contained building block for power switching applications, offer lightweight, low cost and enhanced RAM through simplified design, modularization and reduction of circuit components. The output of this research will be the development of an experimental prototype microprocessor-based power conditioner.

An additional power conditioner research effort consists of the development of advanced power function modules for solid state power conditioning equipment. Power conditioning equipment permits the supply of electric power to users at required voltages, frequencies, and power quality from available indigenous power sources. Modular power switching elements simplify power circuits, improve RAM characteristics of solid state equipment and reduce life cycle costs, thus contributing to the development and user acceptance of power conditioning equipment. This effort will advance power switching technology by the development of modular devices based on state-of-the-art solid state switching elements. The use of advanced switch technology such as power field effect transistors (FET's) will permit simplified, low power, drive circuits and, because of enhanced control characteristics, will result in reduced switching losses and permit higher operating frequencies. Resulting equipment designs will utilize lighter weight, lower cost components, and will exhibit lower audible noise signatures. This area depends on application of advancing power switch technology; the risk associated with that technology is considered moderate at the present time. Pay offs will be in enhanced performance of power modules leading to increased RAM, lower cost and higher power density, contributing to power conditioner development. The technology product of this research will be a variety of solid state modules.

Basic research on materials is planned to obtain basic data on new materials which offer promise of higher efficiency, higher packing density as well as lower cost, when compared to available devices for applications in power switching. At present, amorphous semiconductors are possible candidates, the field is being continuously surveyed for other promising materials. The risk in developing lower cost switching elements is moderate and the pay off in lowered power conditioner costs and higher power density will contribute to development of improved power conditioners and will enhance their ability to meet portability and use of local power requirements.

2) Lightweight Conductors

A basic research effort is aimed at obtaining a greater fundamental understanding of electrical conduction mechanisms in graphite intercalation compounds. These materials, formed by chemical insertion of donor or acceptor species between graphite layers, are being considered for application as new lightweight electrical conductors. Certain of these compounds have been shown to have a conductivity in excess of copper and a density of about one-fourth that of copper. Current research activities

focus on inter- and intracrystalline contributions to the conductivity with future work planned on optimization and stabilization of the resulting compound and to develop highly conducting compounds and establish scientific bases for optimizing these materials as conductors. The goal is demonstration of lightweight, high conductivity wires suitable for exploratory development as cables for distribution systems to permit the Army to supply electric power in a mobile, tactical environment. It is presently envisioned that this work will be ready for transition to exploratory development in the FY 84-85 time frame. Although high conductivity has been demonstrated, enough problems exist that a moderately high risk exists as far as developing lightweight high conductivity electrical conductors is concerned. The pay off from such development is great in meeting requirements for availability and mobility of electrical power in the field.

Optimization of graphite intercalation compounds as lightweight, low loss conductors requires a fundamental understanding of conduction mechanisms in these materials. Low temperature research techniques aid in separating contributions of possibly competing mechanisms and provide data on structural and phase changes which help clarify the interactions involved. Information gained in this area aids in selecting and improving compounds for applications as improved conductors in military power distribution systems.

One project involves the development of improved compounds for applications as improved conductors to adequately support operational requirements and will provide for the accelerated demonstration of low temperature research on electrical conductivity in graphite intercalation compounds.

Difficulties in employing, retrieving, and redeploying cable type distribution systems hamper the Army's ability to supply electric power. One of the problems is the weight of cable system components and, especially, the weight and lack of handling ease of the cable itself. In typical power cables as much as 50 percent of the weight may be attributed to insulation and jacket, thus a reduction in this area can be significant. New insulation materials such as thermoplastic rubbers show considerable weight reduction over standard materials, e.g., neoprene, and have excellent physical properties. This effort aims at reducing cable weight without loss of other desirable characteristics through application of these new materials. Experimental samples have shown weight reductions of 20 percent. Future work is planned to consider other materials, such as foams, and techniques, such as cross-linking. Special requirements such as fuel resistance, flexibility

and flame retardance will also be addressed. Transition to 6.3 is planned for the FY 83 time frame. The risk of successfully applying these materials to power cables is relatively low whereas the pay off in mobility and availability of electric power supply is high. The output of this research project will be the determination of the feasibility of lightweight cables based upon low density installation technology.

c. Special Purpose Generators

1) Stirling Cycle Engine

Stirling engines are representative of external combustion engine technology which continues to be of prime interest for small size power plants (under 10 KW) due to inherent features of multifuel capability, high efficiency, and very low noise level. Current DGE supported technology efforts have resulted in successful component development of free piston linear alternator power plants in the 1 to 3 KW rating. Free piston Stirling engine combustion technology for operation with military fuels will define suitability for Army application. One project will lead to the development of a high efficiency, low noise level, free piston engine to drive special purpose generators under 10 KW size. The technology product will be the development of components for a prototype Stirling engine power unit through an evaluation of the combustion technology, a fabrication and test of combustion components and the assembly for a completed engine.

2) Advanced Heat Engines

Fifty to 200 percent increased specific power capability of advanced gas turbine and diesel power plants applicable to Army generator sets and auxiliary power units (APU) can be achieved through use of high temperature component designs of turbine units, and high speed, high temperature components and turbo-charging of diesel units. A demonstration of the technology and comparison of improved heat engines will be the output of a project.

d. Power for Directed Energy Weapons

Pulse Power Generator - This research will provide high power generation systems which will meet the mobility requirements for directed energy weapons. S&T Base program data on this item is classified with the exception of general descriptive information. To provide pulsed power, a power source using a specially constructed flywheel for energy storage (driven by an engine) which, via appropriate generating high voltage power conditioning equipment, can provide the electrical power required for these projected, large, directed beam weapon systems. The technology product/output of this research will be a first generation prototype pulse power generator for use with forward area laser weapons, and a demonstration of an electric pulse power generator for a developmental laser weapon system.

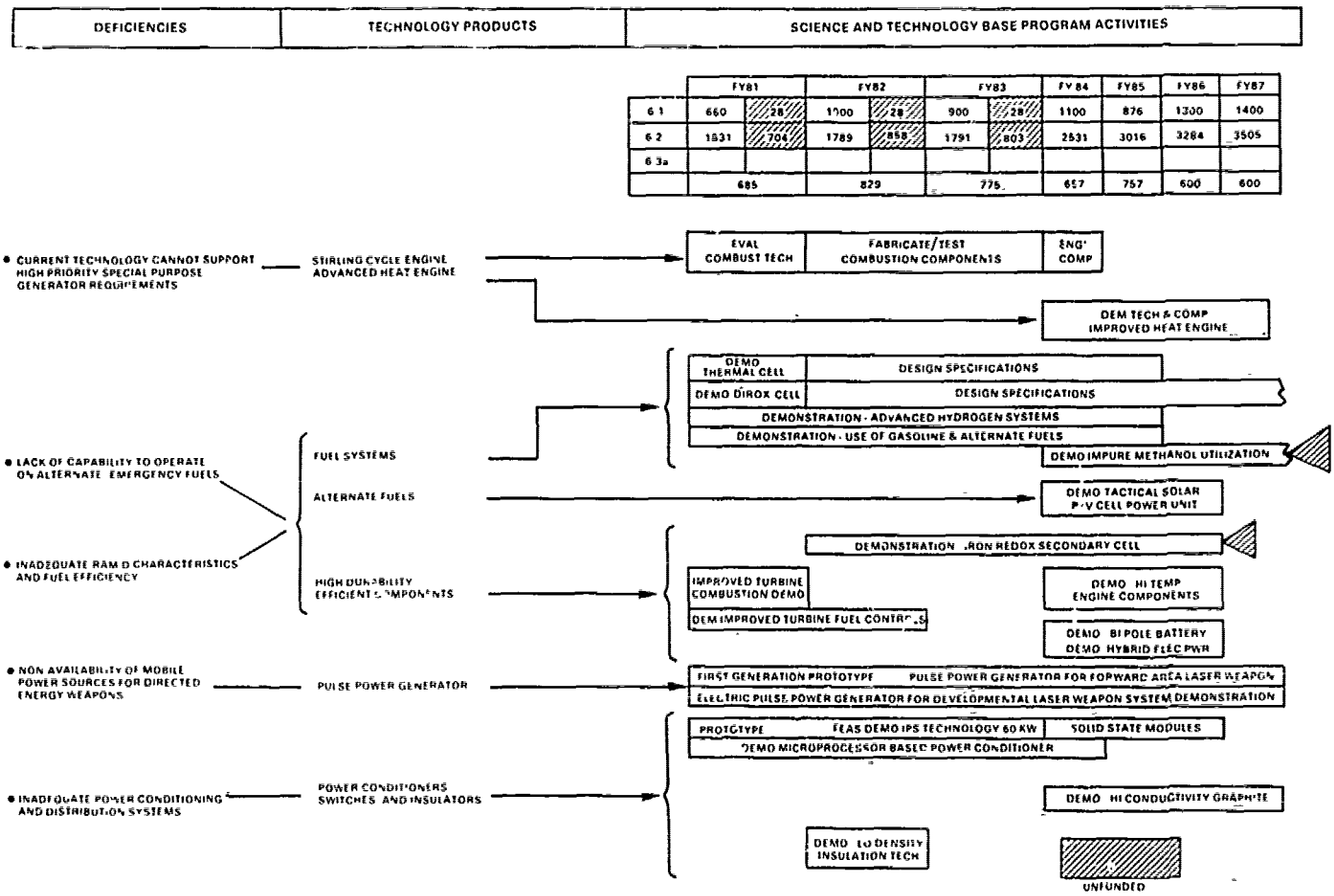

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Figure X-3. USAMERADCOM Electric Power Science and Technology Base Program Activities

CHAPTER XI
FUELS AND LUBRICANTS

CHAPTER XI
FUELS AND LUBRICANTS

A. MILITARY SIGNIFICANCE AND NEED

Fuels and lubricants meeting military unique requirements are essential to maintaining combat readiness and providing weapon system mobility on the battlefields. Projected petroleum-fuel shortages require the rapid adaptation to alternative sources and resource conservation measures.

B. FUNCTIONAL CHARACTERISTICS

The fuels and lubricants field of endeavor comprises the following major functional areas:

1. Fuels

This category includes aviation fuels, automotive gasoline (leaded and unleaded), automotive diesel fuels and heating (burner) fuel oils.

2. Lubricants

This group includes various grades and types of oils and grease for internal combustion engines, vehicles, weapons and other machinery.

3. Fluids

The category of functional fluids consists of hydraulic fluids for power transmission (i.e., automotive brake systems, turret gun control systems, etc.), fluids for artillery recoil mechanisms, and coolants for internal combustion engines.

4. Corrosion Preventatives

This area includes petroleum based preservatives, rust and corrosion inhibitors for cooling systems, and additive stabilizers/extenders.

C. CURRENT CAPABILITY

The Army's current and projected near term capability to fulfill its fuels and lubricant requirements consists of existing baseline equipment as shown in Figure XI-1. Descriptions of these items are contained in Volume II (Fuels and Fuel Handling) and Volume III (Lubricants and Corrosion) of the MERADCOM DIGEST OF EXISTING DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing fuel and lubricant capabilities are summarized below:

1. Fuels

a. Gasoline, Automotive, Combat (MIL-G-3056)

These gasolines are designed to provide efficient operation of the fleet of internal combustion

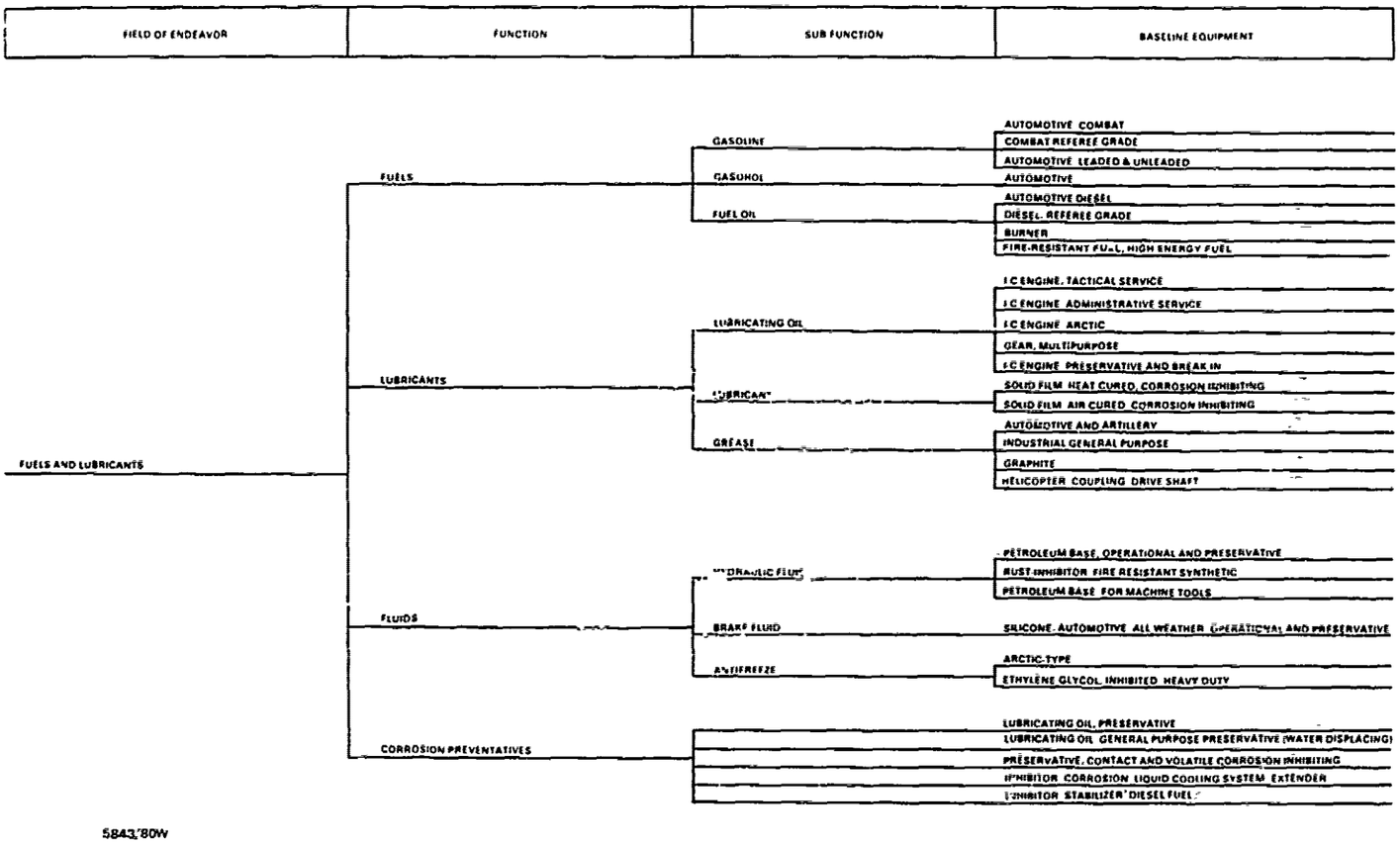

Figure XI-1. Baseline Equipment Summary for Fuels and Lubricants

gasoline engine combat vehicles. Type I is for use in temperatures above 0°F, while Type II (Arctic Grade) is for use when the mean temperature is below 32°F. This fuel is used within NATO under interchange agreements as NATO Code No. F-46.

b. Gasoline, Automotive Combat Referee Grade (MIL-G 46015)

This gasoline represents the minimal quality level of combat gasolines that could be procured under MIL-G-3056. It is designed to be equivalent to that gasoline that could be provided US Forces in OCONUS areas of operation. It is intended to be used for RDTE programs during the development of the engine system.

c. Gasoline, Automotive, Leaded or Unleaded (VV-G-1690)

These fuels are intended for use in spark-ignition internal combustion engines in commercial and administrative vehicles. Variations in grade and leaded/unleaded content are to conform to design criteria of fleet vehicles and regulations/legislation imposed by EPA.

d. Gasohol, Automotive Unleaded (PD ME-103)

Gasohol is composed of 10 percent ethyl alcohol and 90 percent hydrocarbon gasoline by volume. It is intended for immediate use in spark-ignition internal combustion engines in administrative vehicles only, and has not been adequately tested for use in combat/tactical equipment. The Gasohol Evaluation Program to be completed by end of FY81 will confirm the suitability for Gasohol in all gasoline-consuming tactical equipment.

e. Fuel Oil, Diesel (VV-F-800)

These fuels are procured for automotive diesel and compression ignition engines. The three grades of fuel (DF-A, DF-1, and DF-2) provide for optimum efficiency as a function of normal operating environment. This fuel is used within NATO under interchange agreements as NATO Code No. F-54.

f. Fuel Oil, Diesel, Referee Grade (MIL-F-46162)

This fuel is a diesel fuel representing the minimal or marginal quality level which can be procured under specification VV-F-800 while meeting all of its requirements. It is designed to be equivalent to the quality of OCONUS distillate production or that production available in times of national emergency. It is used for research, development and proof testing to assure that equipment will perform adequately with all possible types of diesel fuels procured under VV-F-800.

g. Fuel Oil, Burner (VV-F-815)

Burner fuels are burned under boilers or in furnaces to generate power or heat. Specifications for these fuels are not exacting, although compatibility of

various fuels is important. The gradation of these fuels is chiefly in viscosity and gravity and therefore, in the types of burners required for their use.

D. ACQUISITION ACTIVITIES

All fuels, lubricants and fluids for engines and other equipment use are acquired for the US Army by the Defense Logistics Agency. USAMERADCOM is not directly engaged in acquisition activities for fuels and lubricants.

E. CURRENT CAPABILITY DEFICIENCIES

The current capabilities to meet the Army's requirements for fuels and lubricants are deficient in the following respects:

1. Insufficient Data and Lack of Rapid Test Methodology to Introduce Alternative Fuels

Successful military operations and mission accomplishments depend upon mobility. For the US Army to be able to function, an adequate supply of mobility fuels must be available at all times. With the uncertainties of new crude and syncrude sources being developed, the need to assure suitability of military fuels refined from these feedstocks is of great importance. This is becoming more critical as possible future disruptions of offshore crude will create tremendous fuel shortage problems within this country. Pre-positioning concepts will dictate requirements for fully-fueled storage up to four years where no deterioration or degradation of fuel quality will be permitted. Fuel instability is also being addressed in terms of non-storage environments to increase fuel conservation.

2. Fire Hazard of Fuels and Fluids in Combat Vehicles

Recent combat damage reports have established the fuel and hydraulic fluid threat to be a major problem for armored equipment operating in hostile environments. Conventional diesel fuels when heated to above their flash point (i.e., the lower explosive limit) are highly combustible and generate tremendous fires which not only consume human life but completely destroy armored equipment rendering it non-repairable. Conventional hydraulic fluids employed in armored equipment are also highly combustible when operated under pressure (1000 to 3000 psi) and they also have been found to constitute a fire threat problem.

3. Non-Availability of High Performance Fuels, Lubricants and Fluids for Advanced, Military Engines, Power Trains and Weapons

The development and eventual deployment of future weapon systems will depend a great deal on the availability of adequate fuel and lubricant products in the field. In

many instances, the systems will require completely different fuels, lubricants, and functional fluids. For example, the adiabatic diesel engine will require high temperature/high pressure lubricant materials to enable satisfactory operation of this new engine concept. New advanced high survivability helicopter transmissions will require new high temperature, high extreme pressure fluids.

4. Non-Availability of General Purpose Lubricants and Fluids (Excessive Logistic Burden, and Complex Instructions Which Lead to Equipment Failures)

The proliferation of fluids, lubricants, and proprietary products continues to exist within the military. This creates severe procurement, supply, distribution, and logistic disruption problems. Additionally, the increased number of products becoming available to field users will increase the potential misapplication of products which may cause equipment failure and/or malfunction. New technological developments are needed to:

(1) Reduce this proliferation of products (i.e., making engine oils function as power transmission and hydraulic fluids) and

(2) Provide a capability for adequately describing the military unique requirements of these products.

This latter capability is critical since these methodologies are essential for procurement processes and specification requirements that ultimately describe performance levels.

F. FUELS AND LUBRICANTS SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

Because of the continuing dependence of the United States on foreign petroleum imports, the immediate aim of the Mobility Energy Science and Technology (S&T) effort is threefold:

(1) To provide a multifuel capability for its aircraft vehicles and mobile power systems;

(2) To increase the efficiency of all mobility equipment; and

(3) To conserve non-renewable energy resources as much as possible.

The long range aims of the Army Mobility Energy S&T effort are to develop fuel and energy conversion systems which further reduce energy consumption, increase fuel efficiency of vehicles, rotary wing aircraft and electric power generators, increase use of alternative/synthetic fuels, and obtain a lead position in reducing US dependency on petroleum from foreign origin. The Army Mobility Energy R&D Plan describes and prioritizes the funds, schedules, etc. necessary for the US Army to meet the Department of Army Energy Goals.

We must be able to develop the technology to obtain mobility fuels from non-conventional sources such as

shale, coal, tar sands, heavy oil, and biomass. This technology will encompass the evaluation and testing of new synthetic and alternative fuels, identifying of military engine fuel requirements, and developing a new accelerated fuel acceptance - engine/hardware qualification methodology. Concurrently, we must be able to ensure combat effectiveness and operational readiness of equipment by improving the over-quality of conventionally-refined fuels. This technology is directed to reduce fuel deterioration problems which generate equipment malfunction problems and impact on the operational readiness of Army materiel.

The technology is needed to develop both fuels and fluids which do not add to the fire threat problem and will not combust under those conditions of ballistic penetration. A candidate fire-resistant fuel and non-flammable hydraulic fluid have been identified which appear to significantly reduce or eliminate the fuel-fluid contribution to the fire threat. The technology is needed for further development of these products, to provide the necessary performance in armored combat vehicles and improve overall survivability of personnel and equipment.

All weapons systems, having improved designed RAM-D factors, will require "lubrication-for-life" concepts which necessitate new formulation technologies in fluids, greases, and preservatives. This technology is needed to insure parallel development of candidate mobility fuels and lubricants with the system under development. The failure to conduct these programs will result in the eventual fielding of a new weapon system which will be highly dependent on a sole proprietary product which may not be available OCONUS. Concurrent with this effort, new technologies exist within the marketplace which can be applied to existing weapon systems. These new product technologies can be successfully applied to our current weapon system to improve combat effectiveness and readiness for all material.

Current technological developments are addressing a single oil for the M-1 engine and transmission systems, developing of new laboratory performance test methods, and incorporating greater utilization of recycled constituents into our military automotive lubricants.

2. Science and Technology Base Program and Activities

The following S&T Base Program Technology Products, with their related program activities, are under development to overcome the four major deficiencies discussed in Paragraph E. Figure XI-2 shows the relationship of these products to the deficiencies, along with the schedules and level of funding for the S&T base program activities.

a. Acceptability Standards for New Fuels and Alternative Fuel Sources

The products of this effort are procurement specifications, and acceptance test procedures for new fuels, to include alternative/synthetic fuels derived from shale, coal, tar sands, heavy oil, and biomass, for military use. Specific program activities in the endeavor are:

1) Gasohol

Gasohol, an alternate fuel containing 90 percent unleaded gasoline and 10 percent ethanol, is being evaluated for use in military vehicles. Fleet tests are being conducted, engine durability and fuel handling equipment testing with Gasohol is being evaluated and appropriate blending and distribution procedures are being developed to prepare gasohol specifications for procurement, allowing its use in all gasoline-consuming equipment.

2) Fuel Stabilizer Additive

The fuel stabilizer is an additive package to be used with diesel/distillate fuels enabling combat vehicles to be stored in a full readiness condition, i.e., with fuel tanks full or partially full. The additive package being developed consists of an antioxidant, a biocide, a corrosion inhibitor, a detergent/dispersant, and a metal deactivator. The additive package is intended to protect those fuel-wetted surfaces and the fuel itself from deterioration and degradation.

3) Fuels From Oil Shale

Mobility fuels from oil shale is the initial thrust of the Alternative/Synthetic Fuel Program which eventually includes fuels from coal, oil sands, heavy oil and biomass. These fuels are intended as substitutes for those fuels refined from conventional crude. Shale oil based fuels will be primarily turbine fuel and diesel fuel. Specifications will be developed for each of these fuels. Use of fuels from oil shale is expected to increase availability of mobility fuels.

4) Fuels from Shale/Coal

This involves development of a capability to utilize shale-derived and coal-derived military mobility fuels.

5) Procedure for Accelerated Fuel Acceptance Engine Qualification Test Methodology

Fuel property and performance characteristics are critical to the operation and effectiveness of military equipment. As different crude and syncrude (shale, coal, etc.) sources are developed and become available, fuel characteristics can be expected to vary making it necessary to assure that fuels refined from these stocks are compatible with current and new military equipment. Revised test and new specification methodology will accelerate current procedures used to determine fuel acceptance and

engine/hardware qualification. This will minimize delays in introduction of fuels and assure that adequate supplies of mobility fuels are available at all times.

6) Fuels From Coal Liquefaction Processes

Preparation for procurement specifications for utilizing coal-derived military mobility fuels to be completed by the end of FY85.

7) Field Manuals

Complete field manuals describing use of alternative and field emergency fuels, and procedures allowing their implementation and that of variable quality fuels are to be prepared by FY86.

8) High Energy Fuels

The Army's tactical and combat vehicles have a limited operational range because of limited fuel tank capacity. Specifically, the M-1 tank has a high fuel consumption with no flexibility for increasing fuel tank capacity. The purpose of this effort is to increase the calorific value of fuel per unit of volume. In practice, the high energy fuel is a product having a higher density. A tankful of such a fuel will provide greater energy than conventional petroleum derived diesel fuel and therefore increase the range and payload of the vehicle. The candidate fuels include carbon slurries and synthetic high density liquid hydrocarbons. The new product will improve the operational range and efficiency of tactical and combat vehicles.

b. Specifications for Fuels and Fluids to Withstand Fire and Heat

This project involves preparing procurement specifications for fire resistant fuels and Hydraulic Fluids in an effort to reduce the fire hazard in military vehicles. Figure XI-3 illustrates fire resistant fuel equipment for combat vehicles. The specific program activities are:

1) Quality Assurance - Fire Resistant Fuels

Fire Resistant Fuel (FRF) is expected to reduce the vulnerability of combat vehicles to fire and increase crew survivability by reducing fire hazard. FRF is a self extinguishing fuel that resists ignition and inhibits pool burning. It is intended for use only by combat vehicles in tactical situations during hostile operations. FRF consists of a mixture of diesel fuel (84 percent), water (10 percent), and an emulsifying agent (6 percent). These mixtures will be produced in the field using one or more transportable mixing units. The mixing unit is a developmental item. Mixing units will be located as far to the rear as practical and no further forward than the Corps class III supply point.

Figure XI-3. Fire Resistant Fuel For Combat Vehicles

2) Procurement Specification for FRF Derived From Synthetic Crude

Specifications will be prepared for the procurement of FRF made from synthetically derived diesel fuel to reduce the fire threat hazard in equipment.

3) Procurement Specifications for Non-Flammable Hydraulic Fluids

The non-flammable hydraulic fluid will replace the presently used synthetic hydrocarbon based hydraulic fluid (MIL-H-46170) in armored combat vehicles and completely eliminate the fire vulnerability threat and enhance combat survivability of Army material and personnel. This program also supports DARCOM's FIS-COV and Tank Science and Technology Base Program to reduce loss of life and increase repairability of equipment and, consequently, readiness.

The less flammable hydraulic fluid (MIL-H-46170) designed for military equipment other than armored vehicles has been developed where the high cost of a totally fire resistant fluid is not justified. The effort with this fluid will be directed toward reducing the flammability and improving its low temperature operation.

c. Specifications for Fuel and Lubricants for New Technology Engines/Drive Trains

The products of the S&T effort are specifications that extend the life of fuels, lubricants, power transmission fluids, coolants and preservatives for new weapon systems. This comprises the following program activities:

1) Procurement Specifications for Anti-freeze Extender

A new antifreeze extender composition has been developed that when added to an antifreeze will extend the service life of the coolant. Additionally this inhibitor composition will be incorporated into a coolant filter/conditioner system. The filter/conditioner system will be designed as a spin-on canister type charged with the inhibitor and will be used in conjunction with an electronic corrosion monitoring dev ce that indicates when the canister should be replaced due to additive depletion. With such a system, corrosion of cooling system components will be kept to a minimum and will require only periodic replacement of the filter/conditioner as necessary. Use of this system will greatly reduce the need to change antifreeze and contribute to conserve non-renewable, petroleum derived, resources.

2) Test of Long Life Antifreeze

This involves user acceptance testing of long life improved antifreeze to determine its acceptability for use in tactical and support equipment.

3) Procurement Specifications for Diesel Coolant

The development of a new high temperature coolant is necessary to insure satisfactory operation of new high performance diesel engines currently under development. Operating temperatures and heat output of these new high performance diesel engines will be considerably higher than with the present diesel engines. Existing military coolants will not perform adequately in such engines without detrimental effects to engine durability or coolant life. The development of a new high temperature coolant with greater heat transfer capability will assure adequate operation of high performance diesel engines and give added protection to the presently used diesel engines.

4) Specifications for High Durability Automotive/Artillery Grease

The improved greases will provide the Army the lubricants for vehicles and other equipment capable of operating in a broad range of climatic and environmental conditions.

Salt/fresh water and humidity corrosion resistance will alleviate problems presently associated with military ground and amphibious vehicles and improved RAM-D factors. The expected storage life of military grease is presently 2-5 years. Long life military greases will allow for much extended storage in packaging, vehicles and equipment reducing handling and maintenance time while retaining product quality.

5) Specifications for Advanced Power Transmission Fluids

Advanced hydromechanical transmission systems currently under development for track laying vehicles will be more efficient over the entire speed/power range than present systems. The efficiency improvements are expected to pay off mainly in better low-speed agility, acceleration and fuel consumption. Power transmission fluids will be developed to meet the requirements of this system which will necessitate improved high temperature and high pressure operation combined with high mechanical shear stability and improved fluid film lubrication.

6) Specifications for Solid Film Lubricant

The corrosion protection of the presently used solid film lubricants is based on lead compounds in the formulation. A new, non-toxic and leadfree solid film lubricant will provide equivalent lubrication and corrosion protection for small arms, large caliber weapons, missiles and other miscellaneous items.

7) Specifications for High Efficiency Adiabatic Diesel Lubricant

The Army is engaged in the development of a diesel engine which will operate under near adiabatic

conditions. This adiabatic design requires sustained operation at temperatures well in excess of those capable with current military engine oils (i.e., piston ring temperatures are in excess of 1,000°F). The introduction of a diesel engine oil with the ability to perform in high temperature environments will greatly enhance the probability for successful development of the adiabatic engine. Also the technology associated with development of this lubricant will provide improved performance in current equipment.

8) Specifications for Synthetic Multi-Purpose Grease

A product that lubricates and cleans small arms weapons systems, and protects components from corrosion needs to be developed. The lubricant will allow the weapons systems to function satisfactorily under all environmental conditions. The present weapons systems use two products to meet the above requirements; therefore, the new product will help reduce the logistic burden.

d. Specifications for Multi-Purpose Fuels and Lubricants to Reduce Logistic Burden

The purpose of this effort is to develop fuel lubricants and fluids that will have a wide variety of applications (i.e., multipurpose) to reduce the excessive number of different items presently burdening the logistic system. Activities in support of the effort are specifications for the following:

1) Multi-Purpose Tactical Engine Oil

Current specifications provide single graded engine oils for lubrication of Army tactical/combat equipment. In order to maintain equipment readiness and avoid operational problems (i.e., starting difficulties, equipment damage, etc.), these lubricants must be changed on a seasonal basis. In many cases, the drained lubricant has not been used to its full capacity; thus the necessary seasonal change has resulted in the disposal of otherwise serviceable oil. Replacement of the single grade oils with lubricants not requiring seasonal change will be advantageous to the Army. Such multiseasonal or multigraded oils will increase equipment readiness, improve lubricant utilization, and reduce equipment maintenance and logistic support requirements.

2) Recycled Engine Oils and Functional Fluids

Since the early 1950's re-refined constituent materials have been prohibited from use in military engine oils. This restriction was imposed because of the low quality exhibited by re-refined oils and problems associated with maintaining the consistency of re-refined base stocks. The recent Energy Policy and Conservation Act in 1975 (Public Law 94-163) and Resource Conservation and

Recovery Act of 1976 (Public Law 94-580) call for revised policies to encourage procurement of recycled oil for military and nonmilitary Federal uses. The use of recycled products will conserve resources, reduce waste and waste disposal problems as well as meet our national policy in conservation of non-renewable resources.

3) Turbine Engine Transmission Oil

This effort will accomplish two objectives: development of a corrosion inhibited turbine engine oil for Army helicopters and M-1 tanks, and development of multipurpose turbine engine-transmission oil for M-1 tanks and future gas-turbine powered tactical ground vehicles/equipment. Corrosion problems in helicopters have been reported by AVRADCOM and are expected to occur in M-1 tanks because of the use of conventional aircraft turbine lubricants. The multipurpose corrosion inhibited engine-transmission oil will improve RAM and operational readiness of Army helicopters and combat vehicles.

The fielding of the present M-1 Tank presents a departure from all other armored combat vehicles in terms of lubrication policies. All other vehicles (M60/M48 tanks, self-propelled artillery, etc.) use the tactical engine oil (MIL-L-2104) for both engine and automatic transmission systems. The M-1, however, now specifies MIL-L-2104 for the transmission and MIL-L-23699 (a synthetic aviation turbine engine oil) for the engine. If either oil is misapplied, component failure will occur.

4) Accelerated Qualification of Engine Oils

This involves completion of user testing of all-purpose tactical engine oils by the end of FY82 and testing of new turbine engine transmission fluid.

e. Science and Technology Output Other Than Products

In addition to the product specifications listed above, other types of output from the Fuels and Lubricants Science and Technology Program are realized. The technology base program produces the following types of output:

(1) Development of new test techniques and methodologies for defining performance and compositional characteristics of petroleum products;
(2) Solution to user/developer problem(s) not evident in any product specification;
(3) Publication of military handbooks and other DA/DOD publications;
(4) Input to lubrication (lube) orders; and
(5) Patents, technical reports, trade journal publications.

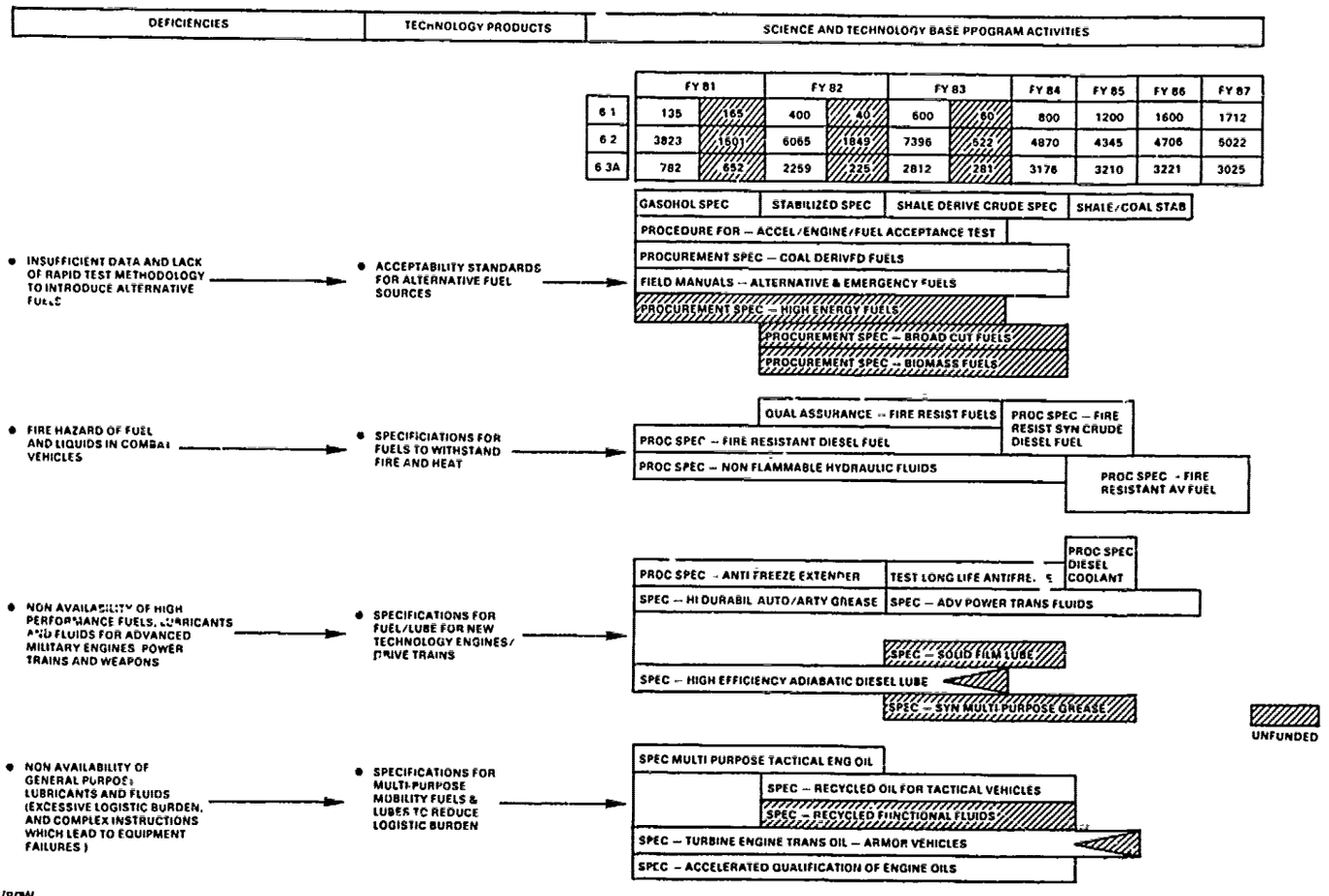

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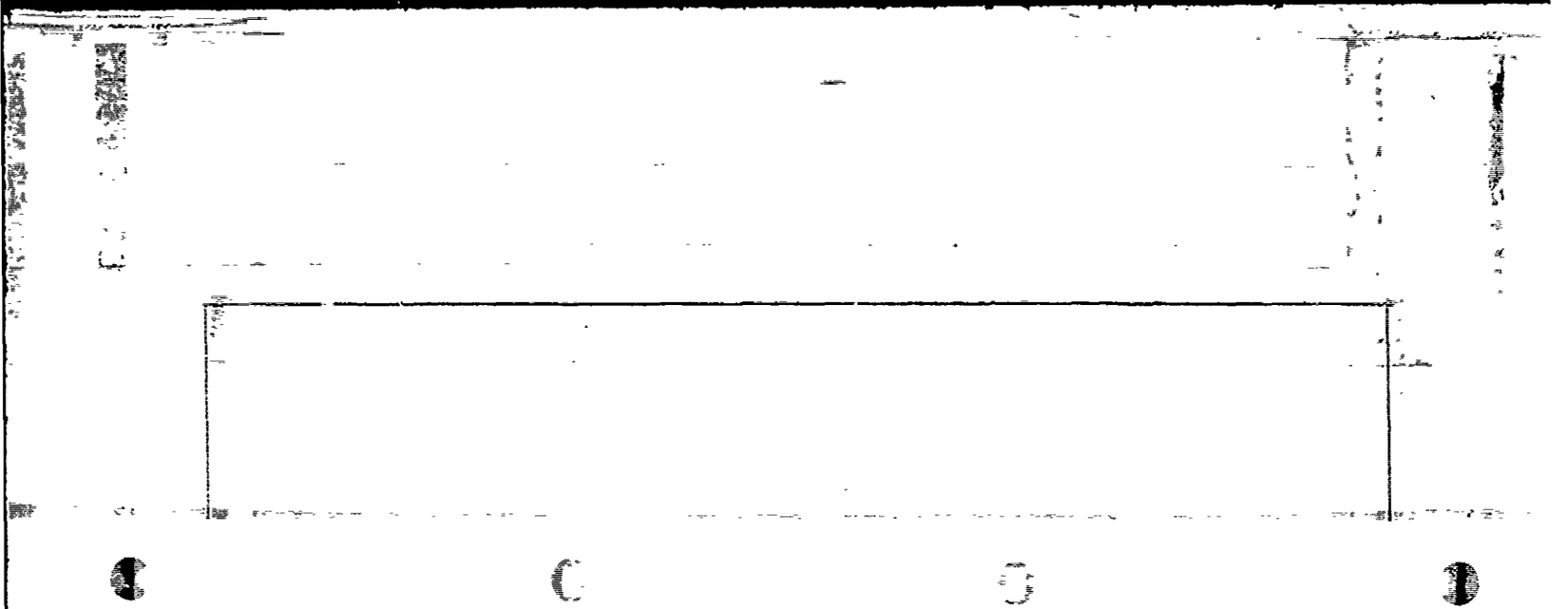
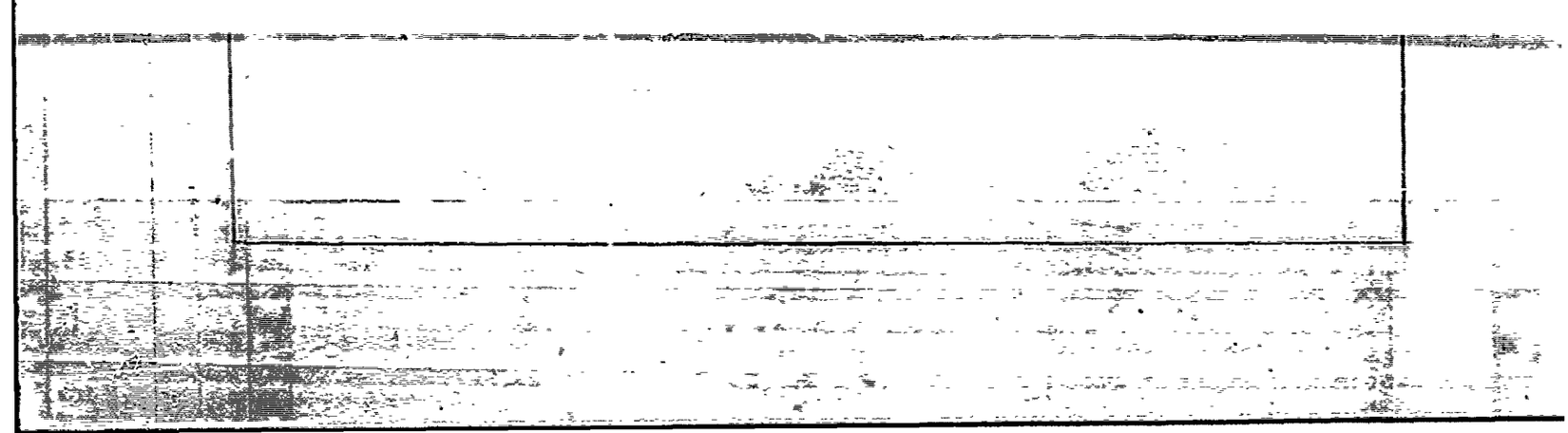
Figure XI-2. USAMERADCOM Fuels and Lubricants Science and Technology Base Program Activities



CHAPTER XII
HEATERS AND AIR CONDITIONERS



CHAPTER XII

HEATERS AND AIR CONDITIONERS

A. MILITARY SIGNIFICANCE AND NEED

Heating and air conditioning systems are essential to the operation of advanced command, control, communication, and intelligence (C^3I) systems which enable US forces to concentrate "fight and win" on the integrated battlefield. Militarized temperature and air quality control equipment is required to keep highly sensitive electronic devices operational under all climatic conditions.

B. FUNCTIONAL CHARACTERISTICS

Heaters and air conditioners can be divided into the following two major functional areas:

1. Heating

This function involves the heating of spaces and equipment by various means to provide habitable conditions for personnel and for maintaining equipment ready for operation within a designated temperature range.

2. Cooling

This function involves the cooling of spaces and equipment, the cooling of liquids, and the cooling of individuals distinct from spaces or equipment when required to function in an environment in which the temperature exceeds that for sustained human performance. Space cooling is accomplished by various means to provide habitable conditions for personnel and to maintain equipment temperature within a required temperature range. Cooling of liquid involves the cooling of potable water under desert conditions to protect the health of personnel. Cooling for individuals involves the maintenance of a temperature range for operating personnel within a vehicle or item of mobile equipment where space cooling is infeasible, and to maintain personnel proficiency under heat stress conditions.

C. CURRENT CAPABILITY

The near term capability of the US Army to meet its heater and air conditioner requirements consists of the baseline equipment shown in Figure XII-1. Descriptions of each of these items are presented in Volume IX of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing heating and air conditioning capabilities are summarized below.

Space heating is accomplished principally by a variety of fuel burning combustion heaters ranging in capacity from 15,000 Btuh to 400,000 Btuh. For small capacity demands, a 5000 Btuh portable electric resistance heater is available.

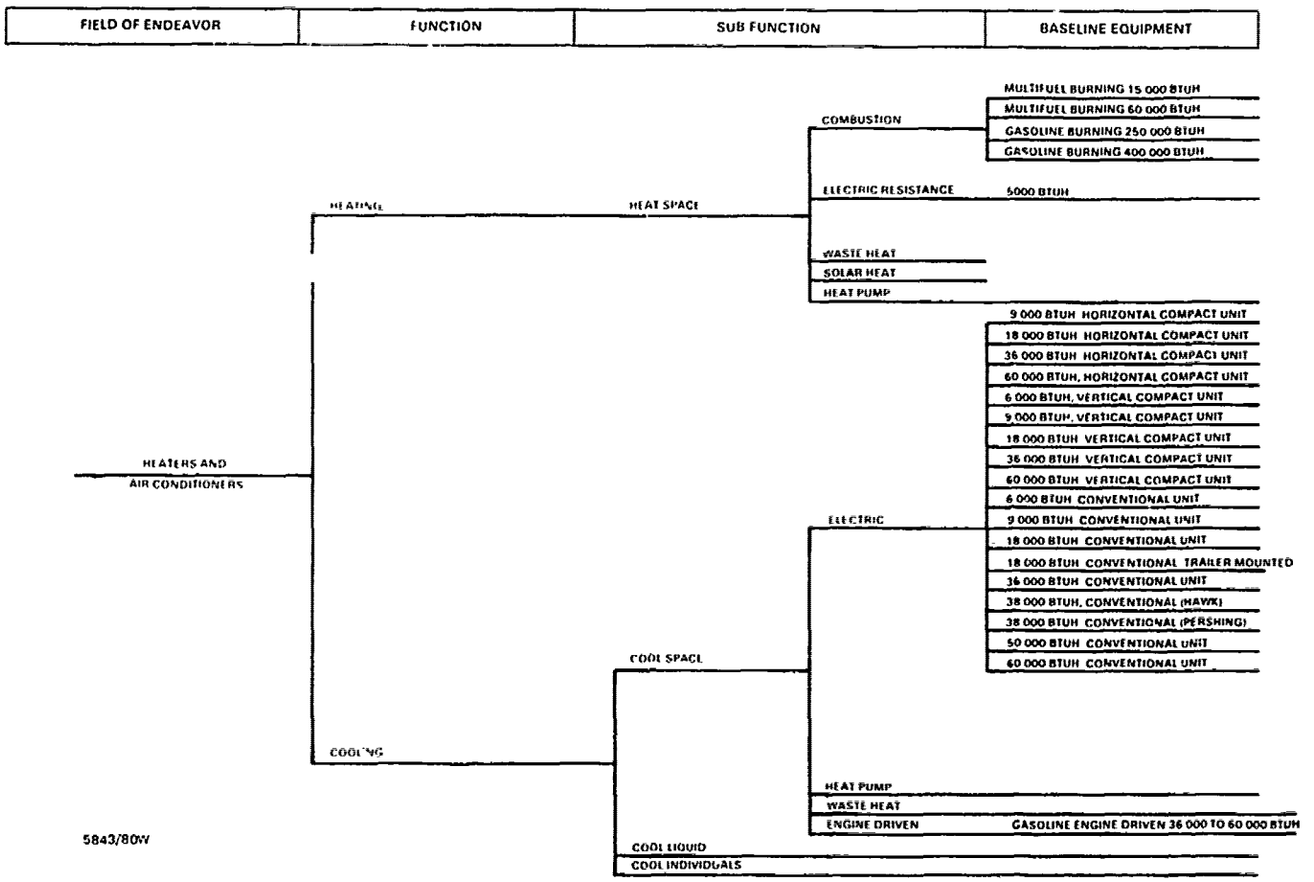


Figure XII-1. Baseline Equipment Summary for Heaters and Air Conditioners

Space cooling is accomplished by a variety of electric powered air conditioning units of different configurations and ranging in capacity from 6,000 Btuh to 60,000 Btuh. Several special design units are available for unique applications such as Hawk and Pershing missile units. Two types of trailer-transportable cooling units are available, one electric driven of 18,000 Btuh which is trailer mounted, and one gasoline engine driven ranging from 36,000 Btuh to 60,000 Btuh which is skid mounted but trailer mountable.

D. ACQUISITION ACTIVITIES

Current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs are shown in Figure XII-2. At present these include new space combustion heaters capable of burning several different types of fuels, a range of electric resistance space heaters of increased capacity, a MACI commercial heat pump for heating and cooling, a series of Improved Van Air Climate Control Systems (IVACCS) for spaces and armored vehicles, a waste heat powered air conditioner, a system for cooling drinking water in the desert, and a Combat Vehicle Environmental Support System (CVESS) which can condition entire crew compartments or circulate air or liquid to cooling/heating garments worn under clothing by the individual soldier. Figure XII-3 shows a 250,000 Btuh combustion space heater under development.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current heating and air conditioning capability and ongoing acquisition activities versus current needs has revealed the following three major deficiencies.

1. Current US Army Temperature Control Systems Have Inadequate Logistical Supportability

The Army buys about 1000 air conditioners each year to cool electronic assemblages used for tactical communications, fire control, missile launching, maintenance shelters, and similar applications. All of the air conditioners use the vapor compression (Freon) cycle to produce the cooling effect inasmuch as the vapor cycle is the most efficient practical refrigeration cycle known. But this singular advantage is negated by a poor RAM history and logistic requirements of high pressure refrigerant cylinders and a special refrigeration tool kit. About 25% of all new vapor cycle air conditioners malfunction. The unacceptable RAM can be attributed to the complex high pressure refrigerant system that includes several electromechanical components (hot gas bypass) which allow the system to operate continuously regardless of load, thus preventing electric

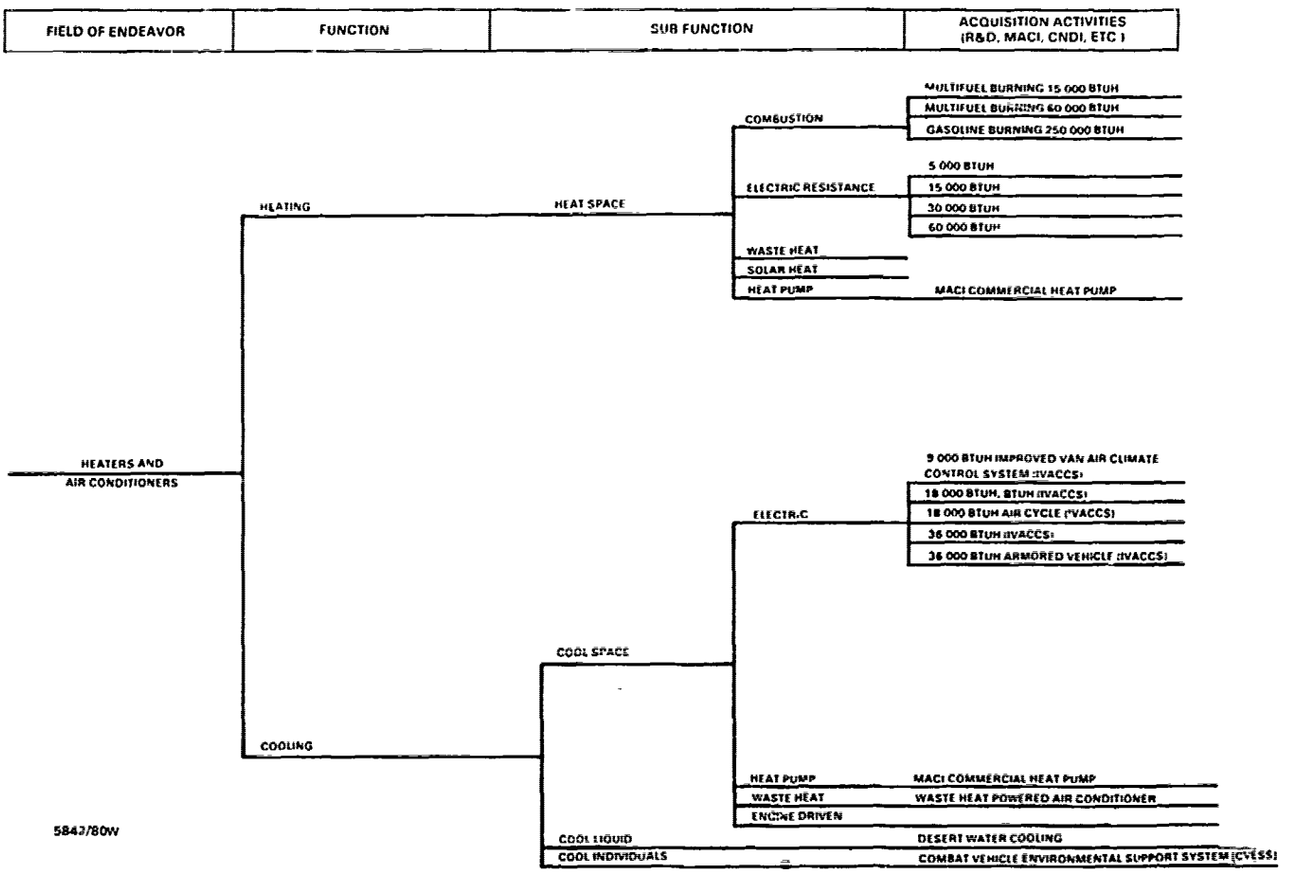


Figure XII-2. Summary of Heating and Air Conditioning R&D Materiel Acquisition Activities

Figure XII-3. 250,000 Btuh Combustion Space Heater

magnetic interference (EMI). The piping system interconnecting these electromechanical components creates countless joints and many feet of small diameter copper tubing subject to failure by the shock and vibration of rough terrain transportation. The Army vapor cycle air conditioner is a complex, somewhat fragile air conditioning mechanism.

Required continuous operation of vapor cycle air conditioners defeats the inherent high efficiency of the cycle and results in a very high fuel consumption. Usually electrical power for tactical systems is produced by internal combustion engine driven electrical power generators that supply electrical energy for shelter mounted electronic systems and the air conditioners that cool the equipment. 50% to 75% of this electrical energy is consumed by the air conditioning equipment because it must operate continously, drawing 90% of rated power when in bypass mode even though no cooling is produced.

2. Current Technology Cannot Support High Priority Special Purpose Heating and Air Conditioning Requirements

Improved enemy response time, target acquisition capability, range and accuracy of enemy weapons indicate that in the 1982-1992 time-frame, vans housing tactical electronic systems will be subjected to an increased threat of hostile fire and battle damage. The newest temperature control equipment was designed 15 years ago and does not meet the battlefield requirements of today.

Specifically the PATRIOT Missile System is being cooled with interim cooling equipment because the technology to supply variable cooling capacity has not become available because of a lack of funds and manpower. Also, the PERSHING Missile System has an immediate need for special purpose air conditioning equipment that is unavailable from the existing inventory. A crash program to modify existing hardware is in progress but the cost-effective solution to PERSHING's needs is yet in the future.

On a larger scope is the need for the cooling of personnel in armored vehicles. The threat from our enemies has clearly shown the need for equipment to permit armored vehicles to operate in an NBC environment. An act of Congress initiated this effort for which there is no existing equipment. The need is so new and the technology so little known that the best refrigerant cycle and distribution system has not been determined. This urgent need will eventually involve several classes of armored vehicles.

3. Current Systems Do Not Incorporate Energy Conservation Measures and are Wasteful in Terms of Fuel Consumption and Peak Power Demand

Increased emphasis on energy conservation has dictated the need to investigate energy savings methods in

all potential areas. Due to the present design and technology employed in air conditioning units, continuous operation of the units results in very high energy consumption.

F. HEATER AND AIR CONDITIONER SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies cited above, a number of MERADCOM S&T efforts have been initiated. These initiatives show significant promise for advancing the capabilities of heaters and air conditioners for the Army. These initiatives include the following:

a. Damage Resistant Air Cycle Air Conditioner

An effort designed to provide a special purpose air conditioner with high RAM characteristics and low logistic burden for several classes of armored vehicles and to meet special purpose needs. Work to date has concentrated on means of improving the air compression and expansion process efficiencies thus improving the coefficient of performance of air-cycle air conditioners to make them competitive with vapor-compression units.

b. Waste Heat Powered Absorption Cycle Air Conditioners

By using high temperature engine exhaust gas heat to power the heat-operated, absorption-refrigerated cycle, air conditioning can be produced with as little as 25% of the electrical energy consumed by a comparable electrically-powered Army air conditioner. The concept has been previously demonstrated using the waste heat of an Army 30 Kw diesel engine generator set to power a prototype 3-ton air conditioner.

This effort is designed to develop a system that can save 75% of the fuel energy presently used to operate electrically powered air conditioners. To date, efforts have concentrated on design requirements for the exhaust gas heat exchangers to be used and corrective means for dealing with diesel soot fouling and sulfate corrosion.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in paragraph E. The relationships and schedule of activities are shown in Figure XII-4.

a. Special Purpose Temperature Control

The product of this S&T effort is a feasibility demonstration of an efficient 18,000 Btuh air-cycle air conditioner.

b. Energy Conserving Air Conditioner

The product of this S&T effort is a feasibility demonstration of the waste heat powered absorption cycle air conditioner utilizing a breadboard prototype.

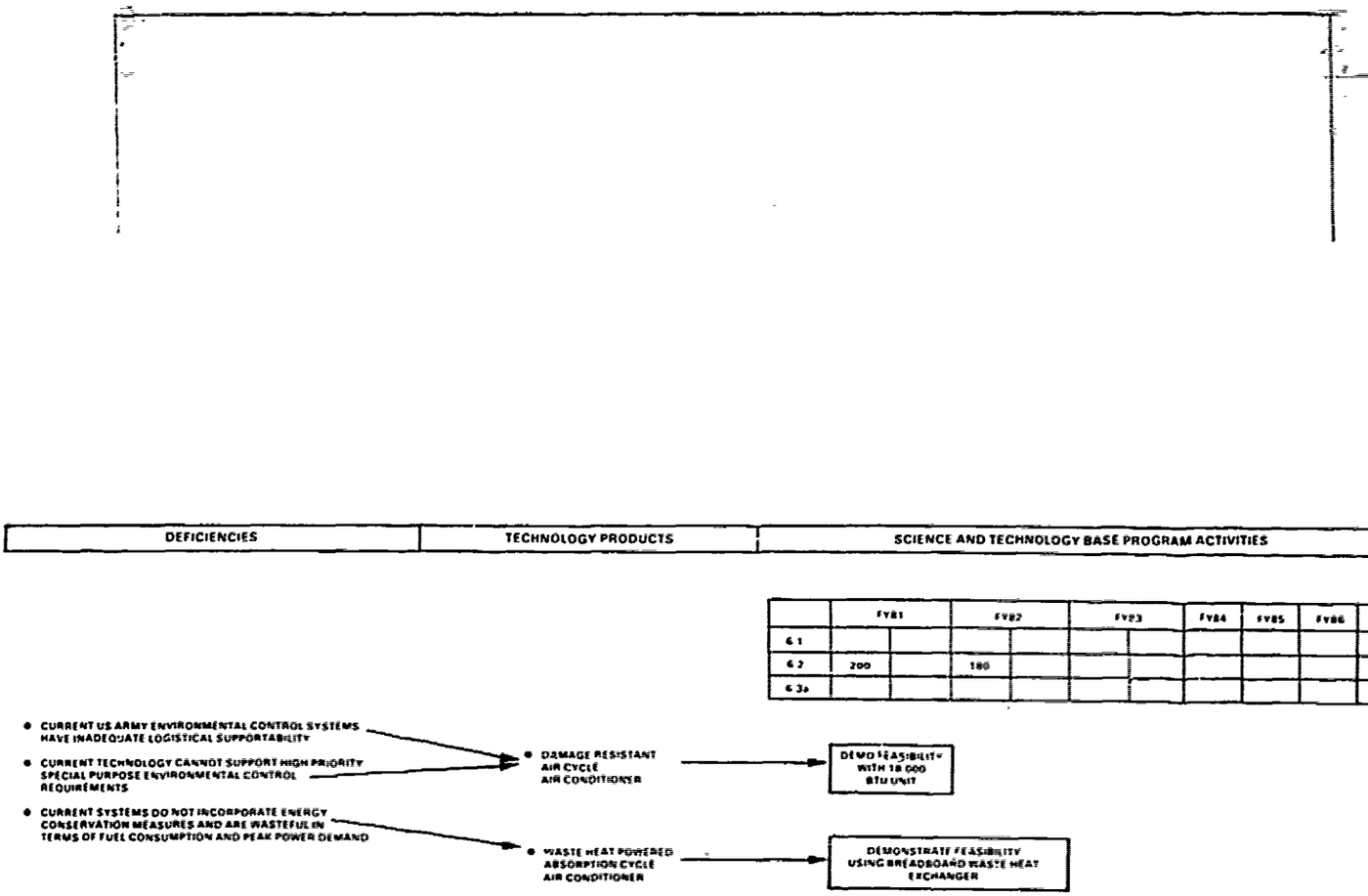


Figure XII-4. USAMERADCOM Heaters and Air Conditioners Science and Technology Base Program Activities

CHAPTER XIII
WATER SUPPLY

CHAPTER XIII
WATER SUPPLY

A. MILITARY SIGNIFICANCE AND NEED

Water supply is an important requirement during military operations for support of the needs of the individual soldier; vehicle utilization; mess activities; maintenance and hospital functions. Most, but not all, requirements are for potable waters. Requirements vary depending on activity and location; however, care must be used in establishing total requirements for mobile operations in a desert environment, especially with regard to source of supply, means of distribution, and special cooling features.

An adequate supply of water of the requisite quality enables troops to survive and function at full capacity in all battlefield environments. Water also provides the capability to decontaminate critical materiel on the integrated battlefield.

B. FUNCTIONAL CHARACTERISTICS

Water supply requirements can be divided into the following four major functional areas.

1. Production

This function involves the location and development of water sources for the provision of mainly potable water. Supply is from fresh, brackish, sea and NBC contaminated water sources. Providing water in a military operation is an Engineer Service, and the following principles guide their selection of the source.

(1) Use available established public systems to the fullest extent.

(2) Use the existing springs or next the locatable wells.

(3) Use such surface-water sources as rivers, streams, lakes or ponds (including flowing subsurface water found in many dry streambeds of desert regions). In arctic areas water can be obtained from melted snow or ice.

(4) Develop ground-water sources when the sources listed above are not available. This is not a practical source for an army on the move unless the underground source can be rapidly located and exploited, and the surface water sources are highly contaminated.

(5) Finally, if no fresh water source can be found, but sea or brackish water is available, distillation, reverse osmosis, or other desalination units can provide purified water.

2. Treatment

Water treatment processes involve field water purification equipment to make the water safe for human consumption. Four basic processes involved in the purification of fresh water are coagulation, sedimentation, filtration, and disinfection. Coagulation is the process of adding chemicals to the water to produce a floc or to destabilize the colloidal suspension of clays or other suspended materials in order to form fast settling aggregates of the suspended solids. Sedimentation is the natural settling of solids heavier than water. Filtration consists of passing the water through some porous material to remove the suspended impurities. Disinfection is accomplished by adding chemicals to kill disease producing organisms. For normal field water purification continuous flow type equipment is used. Demineralization equipment may be required when the source has a high dissolved mineral content. Distillation or reverse osmosis equipment is required for brackish or sea water. Desert conditions may require cooling of the potable water.

3. Storage

This function involves the temporary holding of the potable water between the source and military-user unit employing ground or elevated tanks, pipelines, bladders and mobile carriers. These storage facilities provide a reserve for peak loads and during emergencies such as firefighting, NBC decontamination and breakdown of pumping equipment.

4. Distribution

This function of the water supply system concerns the process of getting water from the water point to the place where it is to be used by the military consumer. In forward combat areas this is done with water cans, trucks or trailers. In rear areas trucks and tank cars transport water to several central storage facilities where further distribution may be made by a system of pumps, pipes, and pipelines. Helicopters carrying up to 600 gallons of water in drums can provide large volumes of potable water for contingency requirements to troop elements deployed to remote water scarce areas.

C. CURRENT CAPABILITY

The US Army's current and projected near term capability to meet its water supply requirements consists of the existing equipment presented in Figure XIII-1. Descriptions of each of these items are presented in Volume I of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing water supply capabilities are summarized below.

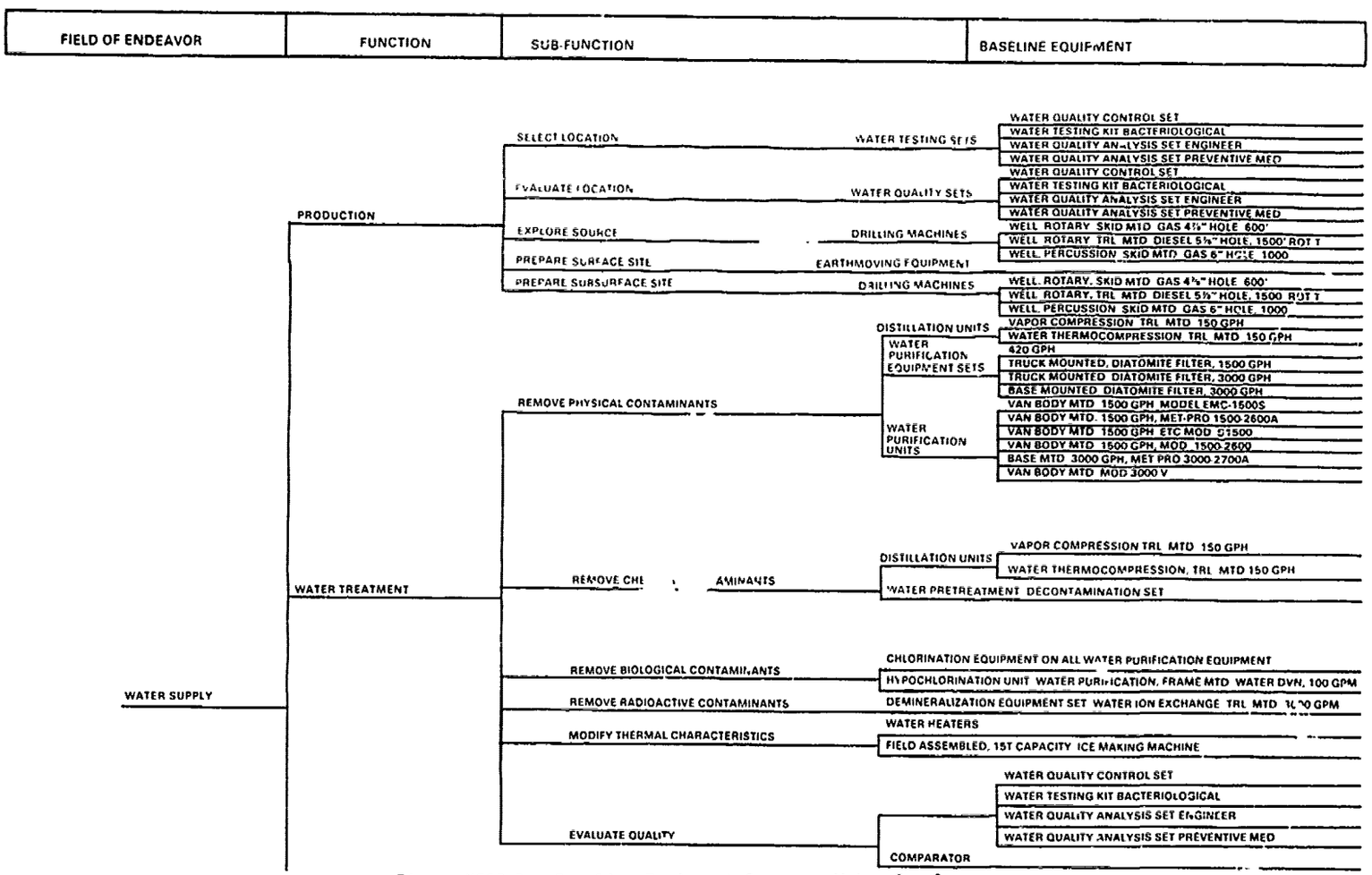


Figure XIII-1. Baseline Equipment Summary, Water Supply

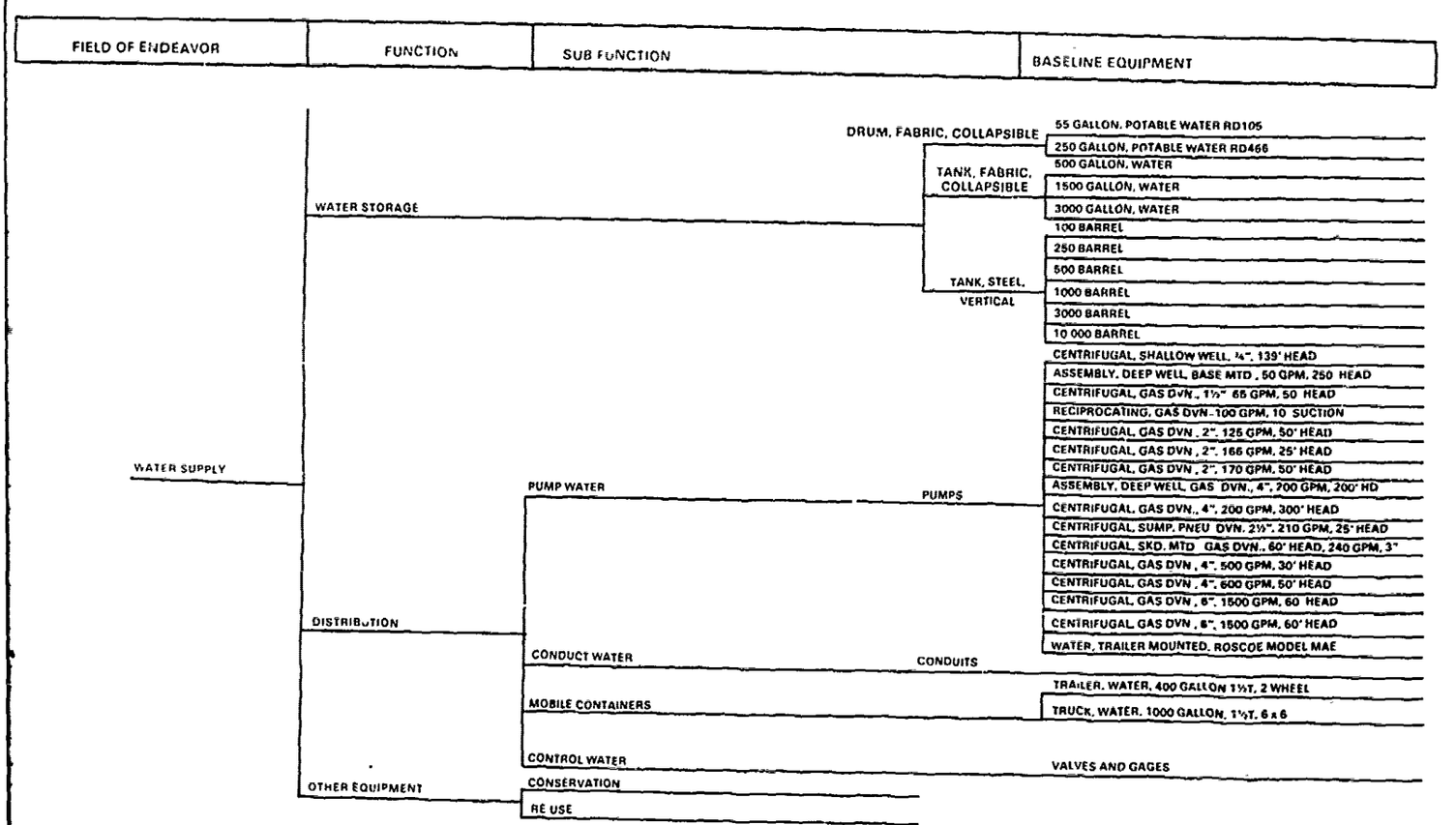


Figure XIII-1. Baseline Equipment Summary, Water Supply (Continued)

The primary well drilling capability consists of the Drilling Machine Well Rotary, Skid Mounted. It drills 4-7/8" diameter wells to a depth of 600 feet. Other units drill to 1000 and 1500 feet. The primary water treatment processing equipment providing for clarification and disinfection are the family of Erdlators with treatment capacities of 420, 1500, and 3000 GPH; the water treatment Decontamination Set for the destruction or removal of agents associated with chemical/biological warfare; and the Water Quality Analysis Set designed to provide immediate information concerning the presence of contamination elements in the water. Of particular interest to military operations in many desert regions is the Distillation Equipment Set, Water Thermocompression for processing potable water from sea water. The primary water storage capability are the 1500 and 3000 gallon Collapsible Fabric Tanks to provide a temporary water storage facility. The primary water distribution capability is the 400 gallon water trailer, the 1000 gallon 2-1/2 ton tank truck and the various centrifugal pump assemblies.

D. ACQUISITION ACTIVITIES

Figure XIII-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs. At present these are focused on the water treatment and the distribution process of the water supply system.

In the water treatment process the basic systems affected by these acquisition activities are the Reverse Osmosis Water Purification units for removing either physical or chemical contaminants from the water supply.

In the distribution process the developments affected by these acquisition activities are the Tactical Water Distribution System and the Forward Area Water Point Supply System.

Figure XIII-3 shows the 3000/2000 GPH Reverse Osmosis Water Purification Unit (ROWPU). A 600 GPH ROWPU recently standardized is in initial procurement.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current water supply capability versus needs has revealed the following four major deficiencies.

1. The Army has Inadequate Capability (Methodology and Equipment) to Detect Water Supplies in Tactical Deployment Areas

There is no available means for the feasible identification of sub-surface water for many tactically important areas where surface water is scarce or non-existent (e.g., arid, hot and cold regions). In addition,

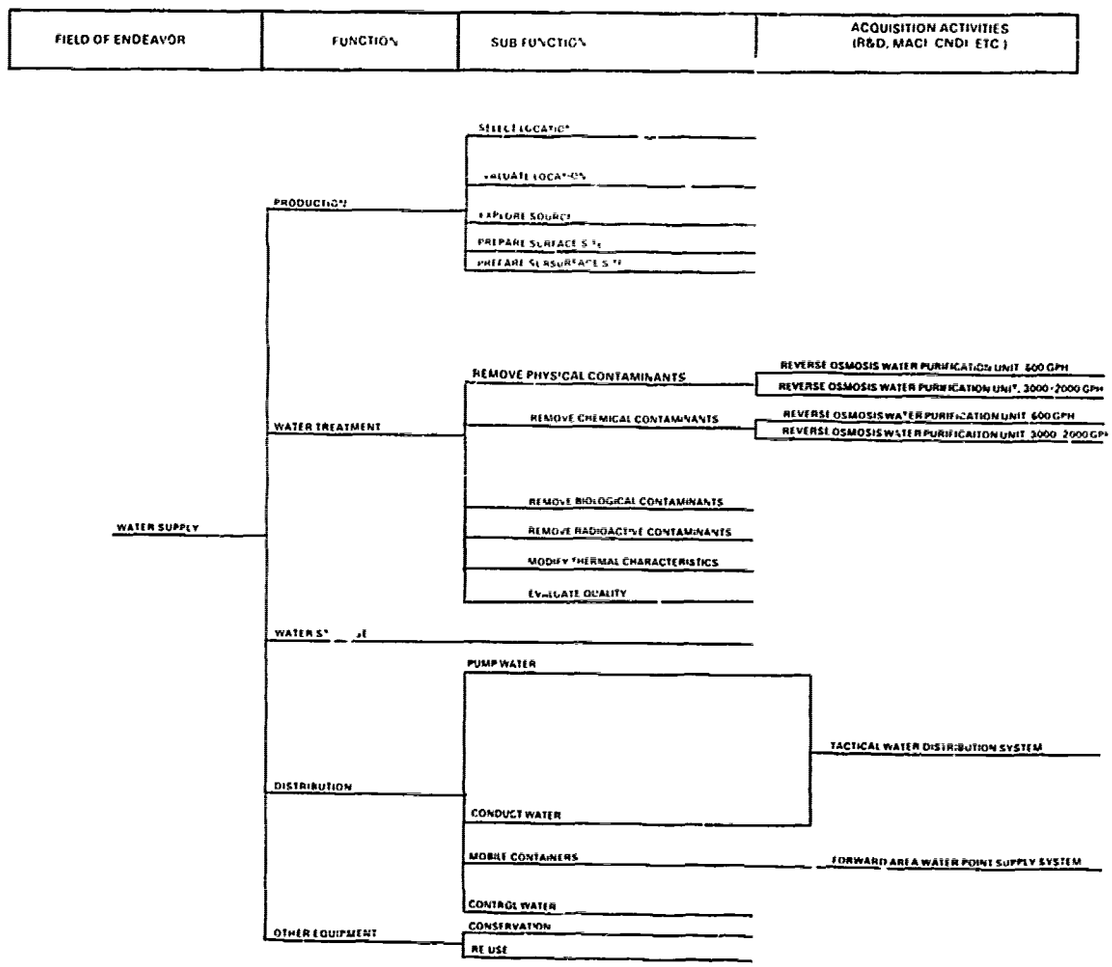


Figure XIII-2. Summary of Water Supply R&D Materiel Acquisition Activities

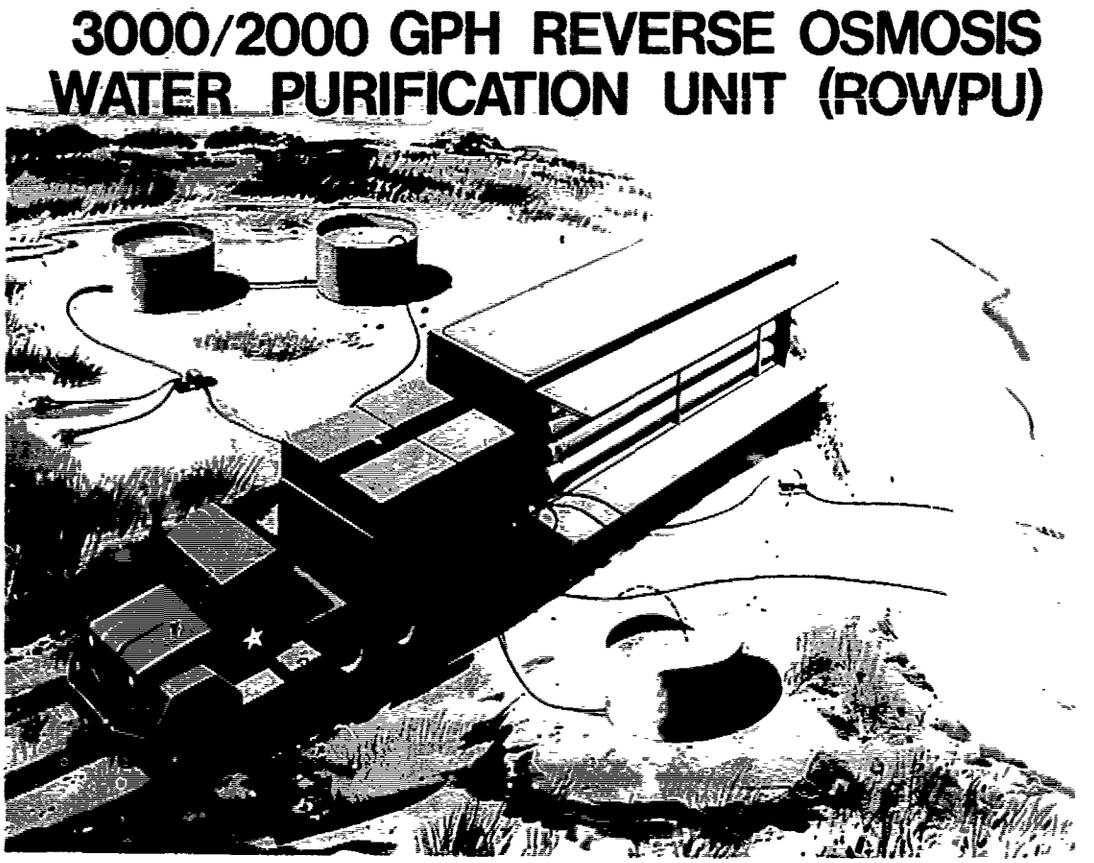


Figure XIII-3. 3000/2000 GPH Reverse Osmosis Water Purification Unit (ROWPU)

there is limited historic data to predict the occurrence of water. The lack of information regarding water supply in possible military deployment areas hampers both logistical and operational planning. For example, available (but dated) British Desert Data show that the shortage of water alone would prevent more than 10 to 12 Soviet Divisions from operating in the trackless mountains and deserts of Iran and Iraq.

2. The Army has Inadequate Capability to Treat or Produce Water on the Integrated Battlefield (Operations in NBC Environment)

The Army has limited capability to develop alternate water sources for military operations where surface water has been contaminated with NBC agents. Much of the current water purification equipment has a limited NBC agent processing capability and new techniques are required for the disinfection of biological agents. Temporary decontamination methods do not permit the capability for extended operations in an NBC environment.

3. The Army has Inadequate Capability to Bring the Temperature of Water Supplies Within Acceptable Limits in Extreme Temperature Environments

There is a need to provide a near term solution to cooling drinking water in a desert environment. Overheated water in storage containers results in excessive evaporation, and increases the number of non-combat casualties resulting from heat stress or dehydration. Energy requirements are high if vapor-cycle (air conditioning) type thermal modification units are employed, and the potential for contamination increases when direct contact methods, such as ice, are used.

4. The Army has Inadequate Capability to Treat and Dispose of Military Unique Wastewaters in Accordance with Current Environmental Regulations

Field Army operations can result in contamination of the environment, particularly water sources, and often cannot meet the pollution standards stipulated by current environmental regulations. Present military efforts for treatment of wastewaters generated during training exercises, especially in Allied countries, on the battlefield are inadequate and time consuming. The problem would be further aggrevated should Army forces be forced to withdraw and reoccupy the area previously contaminated.

F. WATER SUPPLY SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of S&T efforts have been initiated. These initiatives show significant promise for advancing the capabilities of Water Supply Operations.

During World War II and the conflicts that followed in the post-war period, the United States Army fought mainly on battlefields where ample sources of water were available to supply their units and meet their needs. United States political and economic interests are now turning towards those regions characterized by hot, dry and arid conditions. The Army must be capable of meeting the challenge of carrying out military operations under the severe restraints of extreme heat and serious water shortages. In addition, the potential enemies in these regions have shown a willingness to employ chemical warfare and have the capability to employ biological and nuclear weapons as well. The limited water sources in these regions will, therefore, be subject to the additional threat of NBC contamination and the need for large quantities of water to decontaminate more vehicles and material.

To meet this operational challenge, MERADCOM is now investigating means and methods to continue to improve the efficiency of various water purification vehicles, equipment and material undergoing development. The main thrust of the MERADCOM Advanced and Engineering development program is a "Family of Water Supply Equipment" to satisfy the requirements for two different capacity multi-purpose transportable field water purification units based on the reverse osmosis process, namely (1) 600 gallons per hour (gph) unit for Air Mobile/Airborne Division, (2) a 3000/2000 gph Trailer-Mounted Unit. Future systems require improved raw water clarification techniques and membrane technology designed to reduce the potential for membrane fouling resulting in higher rejection of CW agents and to enhance the flexibility and capability of the purification units for treatment of problem water. Disinfection of raw water prior to filtration in purification units eliminates biological fouling of the membranes. Chlorine is commonly used for the disinfection of water. However, due to the high oxidative nature of chlorine it cannot be used for pretreatment disinfection as it causes reverse osmosis membrane destruction, thereby decreasing membrane potable water production.

The potential combat environment envisioned by Army planners mandates development of new technology to locate and rapidly exploit sources of water. If not, then military operations would be restricted to those areas where known water supplies exist.1/

A highly mobile system capable of rapid detection of sub-surface water is under investigation to meet this

1. In the Bolivian-Paraguayan War of 1933-36, military planners on both sides selected as objectives key terrain that would provide superior observation and fields of fire for their combat units; but with the shortage of water the war quickly degenerated into battles for control of wells, streams, and other water sources.

requirement. Technology is being pursued to improve the delivery of water to the surface from shallow and deep wells; to transfer water from one source to another (e.g., moving salt water from the ocean to a central desalination/storage facility); to provide pumps that can move larger volumes of water; to rapidly move tanks and other storage containers of water to remote "bare base" areas.

Evaporation of water in desert regions is rapid and excessive, and the overheated water in large storage containers is not palatable to the combat soldier. Vapor cycle cooling components integrated and assembled on water trailers and storage containers could provide the thermal modifications required, but systems that use less energy are desirable. Field armies generate large quantities of wastewater during mobile field operations. Present technology is being reviewed to reduce or eliminate the problem of contamination that will arise in tactical operational areas which may be subsequently reoccupied. A parallel technology effort will maximize the recovery/reuse of wastewater, thereby, reducing water supply logistics.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in paragraph E. A graphic display illustrating the relationships and schedule is provided at Figure XIII-4.

a. Water Production Equipment

The products of S&T effort will be a body of technical data, physical demonstrations and analytic report concerning assessments of commercial and foreign based technology to identify potential water production equipment and methodologies. Specific activities in this regard are as follows.

1) Exploit Wet Air & Rain

This technology will devise means to provide an integrated system (methodology and equipment) for providing alternate water sources for military operations. The technology product would be a report showing the feasibility of techniques for water harvesting from rainfall in arid environments. Report would show the potential for reducing the logistics burden of developing well sources. The technology product report will also identify candidate methods for atmospheric water extraction and determine related techniques for squad/individual survival in arid and NBC environments.

2) High Mobility Drill

The technology product will be a report that investigates the feasibility of using small, highly mobile well development equipment (kits) as an alternative to contaminated surface supplies. Benefits resulting should

be the development of a rapid well drilling capability, reducing the burdens of larger systems currently in use, and increasing the potential for continuing tactical operations in a water-scarce and NBC contaminated environment.

b. Subsurface Water Detection System

The S&T product will be a body of technical data, physical observations and assessment of existing foreign and commercially available information regarding water detection technology. Specific actions are as follows:

1) ADP System

The technology product will be an investigative study which would develop a system architecture that will integrate real time, on site, and stored data to predict the occurrences of water in target regions for military deployment. Benefits will provide an advanced water supply planning capability resulting in deployment of minimum field apparatus. Study will also provide an early definition of groundwater search and exploitation strategies.

2) Desert Data

The technology product will permit an identification of feasible subsurface water technology for specific tactically important areas (e.g., Egypt, Saudi Arabia, Iran, Iraq) where surface water is scarce or non-existent. Benefits would provide the basis for development of specific groundwater detection devices and the feasibility of technology for military application.

3) Evaluate Subsurface Water Detection Equipment

The technology product will be an investigative use of available water detection technology for input into an integrated water detection concept system. Benefits would permit the development of prototype mobile systems for the rapid detection of subsurface water. In future military operations surface water supplies could be eliminated as key terrain objectives.

c. Improved Reverse Osmosis water Purification Unit (ROWPU) NBC Capability

The product of the S&T effort will be a body of technical data, investigative studies, physical demonstrations, and assessments of foreign and commercial based technology to identify equipment and methodology that can provide better water treatment techniques on the integrated battlefield. Specific activities are as follows:

1) Evaluate ROWPU Clarification Techniques

The technology product is a report that will identify the optimal pretreatment and clarification technologies for ROWPU. Benefits expected from the new technology would be reduction of life cycle costs of the ROWPU with improved reliability of the pretreatment system (including improved membrane performance) during field

operations and improved RAM characteristics as MTBF, backwash frequencies and maintainability.

2) Identify Membrane Fouling Causes

The technology product is an investigation that will identify the mechanics and chemistry of current Reverse Osmosis membrane fouling. The results will provide more complete information on the cause of current RO membrane limitations; identify specific pretreatment requirements for improved ROWPU performance; and the operational characteristics of ROWPU against various field raw water sources.

3) Evaluate Membrane CW Rejection

This technology product will establish baseline correlation of Reverse Osmosis membrane rejection characteristics between chemical warfare agents and candidate chemical warfare simulants. Benefits include acquiring information on the RO membrane CW transport phenomena and identification of those CW simulants which can be used safely to evaluate RO membrane transfer mechanisms for CW threat agents. A larger number of CW threat agents per membrane could be evaluated in-house through the use of CW simulants.

4) Evaluate the Nuclear Threat

Technology product will identify expected levels and types of contamination in water sources by nuclear warfare agents. Results will provide an identification and quantified estimate of the soluble radioisotopes which must be removed by RO membranes thereby defining RO membrane design parameters specific for nuclear warfare agent removal.

d. Closed Wastewater Treatment Systems

This technology product will assess available recycle/reuse technology for water and wastewater to determine the military applicability to closed environmental systems for tactical vehicles and reduced logistics for non-potable water supply in water short areas. Benefits will provide an assessment of technology to optimize the use of a limited supply of water for closed system life support and increase the potential for NBC survivability and to carry out sustained operations.

e. Water Analysis Equipment

The product of the S&T effort will be a body of technical data, physical observations, feasibility studies, and assessments of foreign and commercially available equipment that can identify improved Water Analysis Equipment for field army applications. Specific activities are as follows.

1) Automatic Digital Water Analysis Equipment

The technology product will be the identification of candidate systems and identification of the state-of-the-art technology.

2) Comparison of Chemical and Electronic Methods of Water Analysis

The technology product will determine the precision and accuracy of electronic methods as compared to standard methods for water analysis. Results will provide a rapid method for assessing water quality; be simple to operate; and reduce the need for replacement chemicals in the field.

3) Detection of Nuclear Radiation

This technology product will assess the feasibility of developing a nuclear weapon agent detection capability for water sources. Results will provide identification of methods to acquire field measurements of radioisotopes in water, provide a field capability to accomplish the analysis; and provide analysis at the OTSG requirement level for radioisotopes.

f. Non-Chlorine Oxidation System

This effort will assess foreign and commercially based technology to identify alternates to the use of chlorine for pretreatment disinfection of water prior to eliminating biological fouling in ROWPU membranes. Evaluation would be made of a prototype non-chlorine oxidation system modular. Specific activities in this regard are as follows:

1) Identify Chlorine Alternatives

The technology product is an investigative study for the assessment of foreign and commercial based technology to identify candidate alternatives to enhance ROWPU operations. Possible alternatives are ozone; ultraviolet radiation; ozone/ultraviolet radiation combination; chlorine dioxide; and bromine compounds.

The benefit to the Army would be the identification of the candidate non-chlorine oxidative disinfectant to be used in developing the modular prototype mentioned above.

2) Oxidation/Decontamination Modular Prototype

The development of a modular unit capable of independent oxidation/decontamination used in conjunction with the ROWPU will result as the technology product. This modular unit would allow effective pretreatment disinfection methods and permit the production of potable water without biological membrane fouling in the ROWPU.

g. Mobile Wastewater Disposal Equipment

The product of the S&T effort will be a body of technical data and physical observations that will identify technologies to treat and dispose and reuse wastewaters unique to military operations. Specific activities are as follows:

1) Assess and Demonstrate Treatment Unit

The technology product will expand the science and technology base to identify the most feasible methods for treatment and quantify the benefits of treatment and disposal of wastewater generated during mobile field army operations. Options will be formulated for technological opportunities in mobile field army wastewater treatment, disposal techniques and means and methods to reduce or eliminate contamination of the environment. In addition the technology product will demonstrate the feasibility of recovering/reusing wastewater in order to reduce water supply logistics.

h. Field Water Cooling System

The products of this S&T effort will be a analytic report concerning the adaptability of commercial water cooling equipment to military field water supply equipment and physical demonstration of the value of using the vapor cycle cooling components and of using heat absorption cycle components. Specific activities are as follows.

1) Evaluate Available Water Cooling Equipment

The technical product will report on available foreign and commercial water cooling (and heating) equipment to determine adaptability of technology for mobile field army use. Benefits would provide baseline science and technology information on thermal modification of water supplies; assess the feasibility and operational worth of using available equipment for thermal modification of field water supplies; formulate options for technological opportunities in thermal modification of water supplies.

2) Demonstrate the Vapor Cooling Cycle

The technology product will be physical demonstrations showing the feasibility of integrating commercially available vapor cycle cooling components on a 400 gallon water trailer, and the water cooling effect measured over the full range of specific operational environments. Benefits to be gained would provide an indirect contact, and therefore, a less contaminated (e.g., ice) method for cooling water. Drinking water would meet OTSG recommended levels for temperatures. This system would provide a mobile, near term solution to cooling water in a desert combat environment, resulting in fewer heat stress and dehydration casualties.

i. Waste Heat Absorption Cycle

The product of this S&T effort will be an investigative study with a physical demonstration of the value of using heat powered absorption cycle systems for thermal modification of water supplies. Specific activities are as follows:

1) Feasibility Demonstration of the Heat Powered Absorption Cycle System Equipment

This technical product will determine the feasibility of using an engine exhaust heat powered absorption cycle system for thermal modification of water supplies. There should be savings in energy requirements up to 80% over vapor-cycle (air-conditioning) type units, and would enhance the mobile near term solution to cool drinking water in a desert environment.

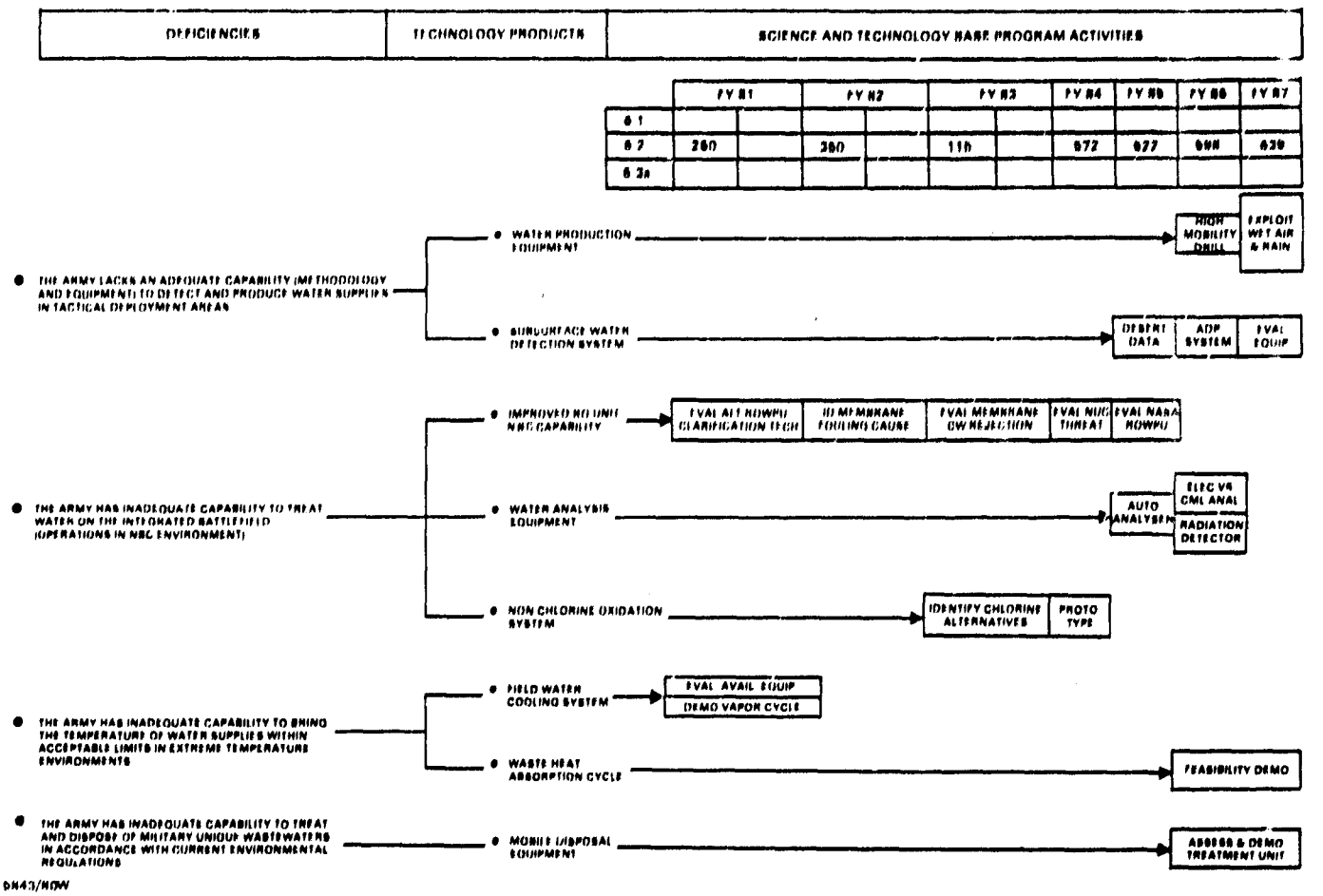


Figure XIII-4. USAMERADCOM Water Supply Science and Technology Base Program Activities

CHAPTER XIV
FUELS HANDLING

CHAPTER XIV
FUELS HANDLING

A. MILITARY SIGNIFICANCE AND NEED

Fuels handling equipment is essential to providing theater forces with fuel at the increased rates and diverse locations required by the modern integrated battlefield.

B. FUNCTIONAL CHARACTERISTICS

Fuels handling can be divided into the following seven major functional areas:

1. Receiving

This function involves the transfer of petroleum fuels from tank trucks, tank ships, and rail cars to storage facilities. The principal subdivisions of this function are Truck Unloading, Ship-to-Shore Unloading, and Railcar Unloading.

2. Storage

This function encompasses both permanent and temporary types of fuel storage to meet a variety of contingencies and site requirements. The major categories under this function are Bolted Steel, Collapsible, and Tanker.

3. Land Transfer

This function involves moving fuel between storage mediums, cross-country, to or within corps or division areas of operation. The four subdivisions of this function are Pump, Pipe, Control, Haul.

4. Filtration

This function provides that only clean, dry fuel be delivered to military aircraft, equipment, and vehicles. This is accomplished by a filtration/separation process to remove solids and water.

5. Testing

This function provides for quality testing of fuels used in military aviation, ground equipment, and the laboratory.

6. Dispensing

This function provides capability in refueling in tactical and forward areas and in rapid refueling at division and corps airfields. The categories under this function are Skid Mounted, Portable, and Tanker.

7. Integrated Systems

This function provides fuel supply and dispensing systems and mobile supply stations in forward combat areas and in an arctic environment. The major subdivisions of this function are DS Storage and Dispensing, Ship Mooring and Unloading, and Tactical Refueling.

C. CURRENT CAPABILITY

The Army's current and projected near term capability in fuel handling consists of existing baseline equipment shown in Figure XIV-1. Descriptions of each of these items are presented in Volume II of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing fuels handling capabilities are summarized below.

1. Unloading

a. Truck Unloading

Tank trucks are utilized to unload fuel from storage tanks.

b. Ship-to-Shore Unloading, Tanker Mooring System, Multi-Leg, Tactical

The system consists of buoys held in place by explosive anchors, boat launching and recovering equipment, motor surf boat, mooring site underwater survey equipment, and a ship-to-shore 6 inch pipeline. The equipment was designed for mooring and off-loading tank ships up to 25,000 DWT in primitive areas where no tank ship off-loading facilities of any type are available. This system gives the Army the capability of quickly establishing a marine terminal in an unimproved area to assure adequate fuel supply for troop operation.

c. Railcar Unloading

Railcars are utilized to unload fuel from storage tanks.

2. Storage

a. Marine, Tactical Marine Terminal

From the tanker moorings, fuel is pumped forward to terminal storage facilities by means of a submarine pipeline and shoreward pumping station. Incoming fuel is routed to one of seven fuel modules for temporary storage or moved to the fuel dispensing assembly, as necessary.

b. Bolted Steel, Tank, Liquid Storage, 500, 1,000, 3,000, 10,000 bbl

These tanks are capable of being assembled on-site by organic troop labor and subsequently used for temporary storage of bulk petroleum as required.

c. Collapsible, Drum, Fabric, 500 gal.

Filled drums are towed or rolled by hand for short distances and can be installed in vehicles for conversion to fuel carriers. In addition, these drums can be delivered by air.

d. Collapsible, Tank, Fabric, 10,000, 20,000 50,000 gal.

The collapsible fabric tanks have filler/discharge assemblies at the top of the tank for receipt and discharge of fuel.

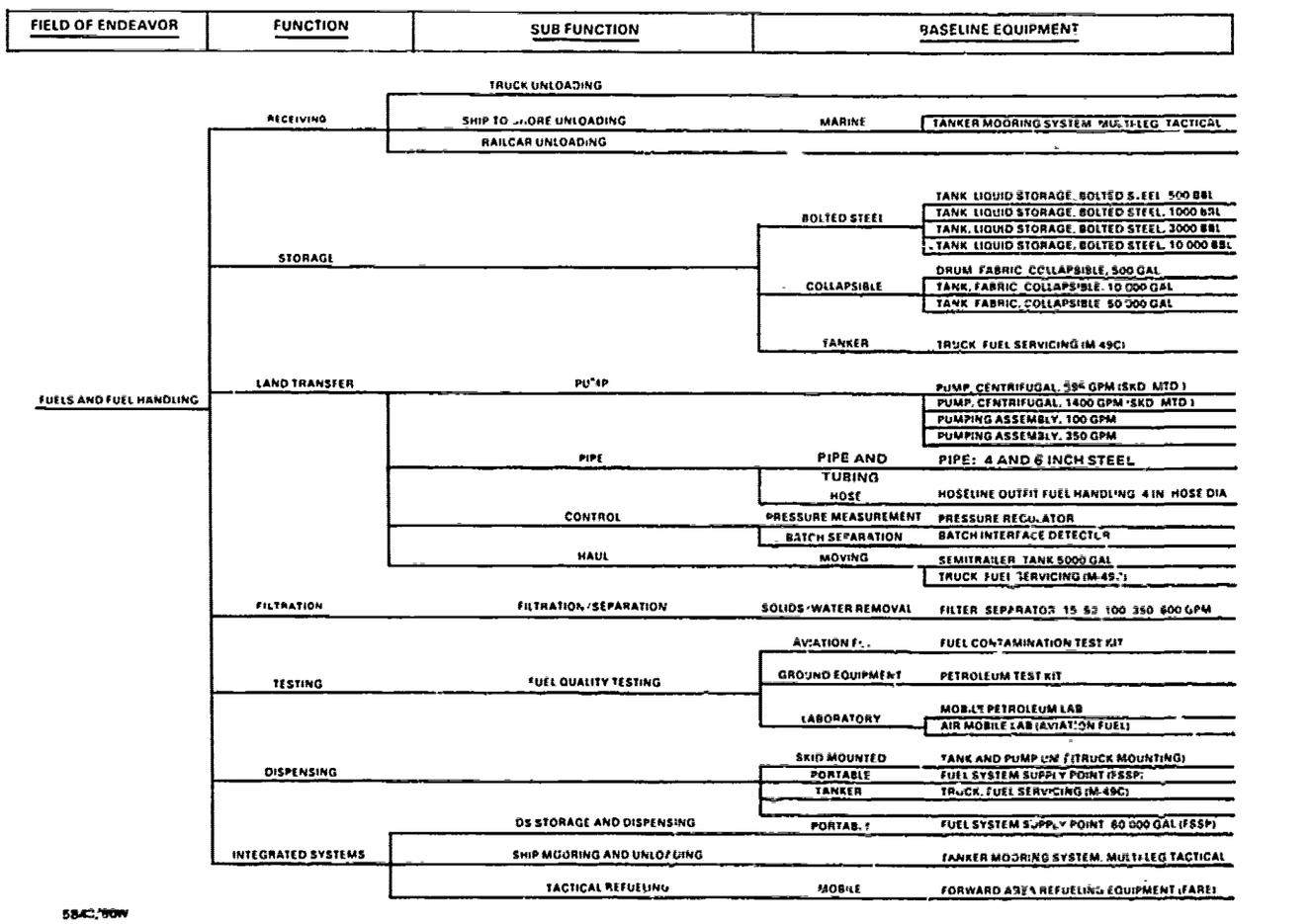


Figure XIV-1. Baseline Equipment Summary for Fuel Handling

e. Tanker, Truck, Fuel Servicing (M-49C)

This is a self-propelled independent refueling unit.

3. Land Transfer

a. Pump, Centrifugal, 595 GPM (Skd. Mtd.)

This pumping unit is a 4-inch, 4-stage petroleum pump which, when installed along a pipeline, serves as a booster pump to restore the required flow pressure to fuel traveling through the pipeline.

b. Pump, Centrifugal, 1400 GPM (Skd. Mtd.)

This pumping unit is a 6-inch, two-stage petroleum pump which, when installed along a pipeline, serves as a booster pump to restore the required flow pressure to fuel traveling through the pipeline.

c. Pump, Pumping Assembly, 100 GPM

The 100 GPM centrifugal pump provides both the required suction and flow pressure to transfer fuel from a storage tank and dispense it into user vehicles and equipment.

d. Pump, Pumping Assembly, 350 GPM

The 350 GPM centrifugal pump provides both the required suction and flow pressure to transfer fuel from a storage medium and dispense it into user equipment. The pumping assembly is used primarily in the 4-inch Hoseline Outfit and in the FSSP (Fuel System Supply Point).

e. Pipe and Tubing, 4 and 6 Inch Steel

This pipe is utilized in pipeline systems for land transportation of petroleum products.

f. Hoseline Outfit Fuel Handling, 4 inch Diameter

The hoseline outfit is a set of equipment which provides a light, compact fuel transportation system which can rapidly move fuel from bulk sources or serve as a branch line from an existing pipeline. The hoseline outfit can transport fuel at a rate of 350 GPM.

g. Control, Pressure Measurement, Pressure Regulator

The pressure regulator is used to regulate flow pressure of fuel traveling through pipeline transportation systems.

h. Control, Batch Separation, Batch Interface Detector

This device is used to monitor and regulate the transportation of fuel batches in pipelines.

i. Haul, Moving, Semitrailer, Tank, 5,000 gal.

This provides the capability to transport large quantities of fuel within corps and division rear areas of operation. The pump assembly provides 600-800 GPM capacity at 150 psi working pressure.

j. Haul, Moving, Truck, Fuel Servicing (M-49C)

This is a self-propelled, independent refueling unit.

4. Filtration/Separation, Solids/Water Removal, Filter/Separator: 15, 50, 100, 350, 600 GPM

The filter/separator removes solid contaminants and water from fuel by use of expendable filter/coalescer elements.

5. Testing

a. Fuel Quality Testing, Aviation Fuel, Fuel Contamination Test Kit

The kit will provide the capability to perform three major measurements for product quality, namely:

(1) Temperature/API gravity

(2) Particulate contamination

(3) Water-in-fuel measurement.

b. Fuel Quality Testing, Ground Equipment, Petroleum Test Kit

Using the various chemicals and equipment in the set, volume measurements, product temperatures, and sample compositions are determined, in order to detect if contamination or deterioration of the POL has occurred.

c. Fuel Quality Testing, Laboratory, Mobile Petroleum Lab

The laboratory uses test procedures and equipment in accordance with the American Society for Testing Materials and Federal Test Methods.

d. Fuel Quality Testing, Laboratory, Air Mobile Lab (Aviation Fuel)

The laboratory uses test procedures and equipment in accordance with the American Society for Testing Materials and Federal Test Methods.

6. Dispensing

a. Skid Mounted, Tank and Pump Unit (Truck Mounted)

The Tank and Pump Unit converts standard 5 ton cargo trucks into bulk fuel transporters and refuelers for other military vehicles and aircraft.

b. Portable, Fuel System Supply Point (FSSP)

This rapidly employable, limited capacity system will be capable of simultaneously fueling ten helicopters with a flow capacity of 600 GPM.

c. Tanker, Truck, Fuel Servicing (M-49C)

This is self-propelled, independent refueling unit.

7. Integrated Systems

a. DS Storage and Dispensing, Portable, Fuel System Supply Point (FSSP), 60,000 gal.

The fuel supply system is intended to refuel convoys, fill 5- and 55-gallon containers, and perform the following functions:

(1) Receive fuel from tank trucks to fill the 10,000 gallon storage tanks

(2) Pump fuel from the storage tanks to the dispensing points

(3) Bypass the storage tanks and pump directly from the tank trucks to the dispensing points.

b. Ship Mooring and Unloading Tanker Mooring System, Multi- Leg Tactical

The system consists of buoys held in place by explosive anchors, boat launching and recovering equipment, motor surf boat, mooring site underwater survey equipment, and ship-to-shore pipeline. The equipment was designed for mooring and off-loading tank ships up to 25,000 DWT in primitive areas where no tank ship off-loading facilities of any type are available. This system gives the Army the capability of quickly establishing a marine terminal in an unimproved area to assure adequate fuel supply for troop operation in this environment.

c. Tactical Refueling, Mobile, Forward Area Refueling Equipment (FARE)

FARE is a versatile system having several fueling capabilities with many combinations of assemblies and fittings for each fueling configuration.

D. ACQUISITION ACTIVITIES

Identified in Figure XIV-2 are current R&D materiel acquisition activities generated from Developmental, MACI and CNDI programs. In addition to these activities shown in Figure XIV-2, a Fire Resistant Fuel Program is also being conducted.

E. CURRENT CAPABILITY DEFICIENCIES

The Army's current capabilities versus current requirements in the field of Fuels Handling reveals four major deficiencies.

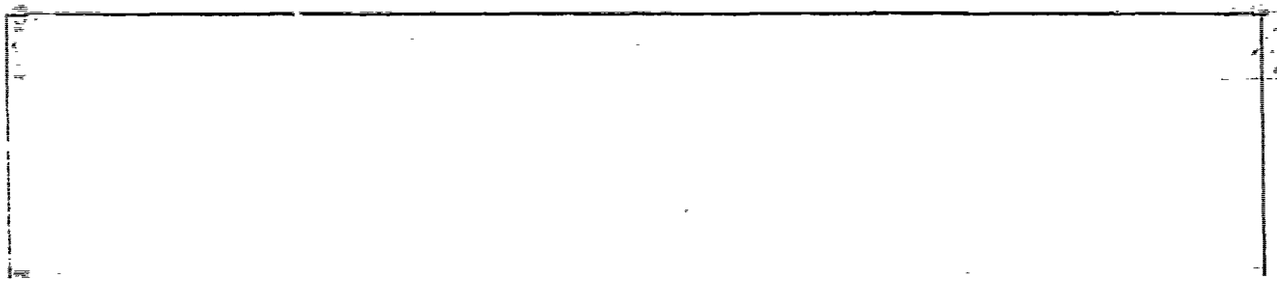
1. US Army is Unable to Move Adequate Amounts of Bulk Fuel in Logistics-Over-the-Shore (LOTS) Operations

The success of a military operation in an undeveloped theater is highly dependent upon the supply of fuel that can be delivered over the beach during the initial and subsequent phases of the operation. Assault forces, engineer construction battalions, logistical supply, etc., require large quantities of bulk fuel to achieve their design potential as a rapid, effective strike force.

Present equipment to meet this demand is limited as follows:

(1) The installation of offshore mooring systems and ship-to-shore pipelines are limited to ideal sea state conditions.

(2) Extensive installation time of offshore mooring system and ship-to-shore pipeline precludes the



FIELD OF ENDEAVOR	FUNCTION	SUB FUNCTION	ACQUISITION ACTIVITIES (R&D, MACI, CNDI, ETC.)

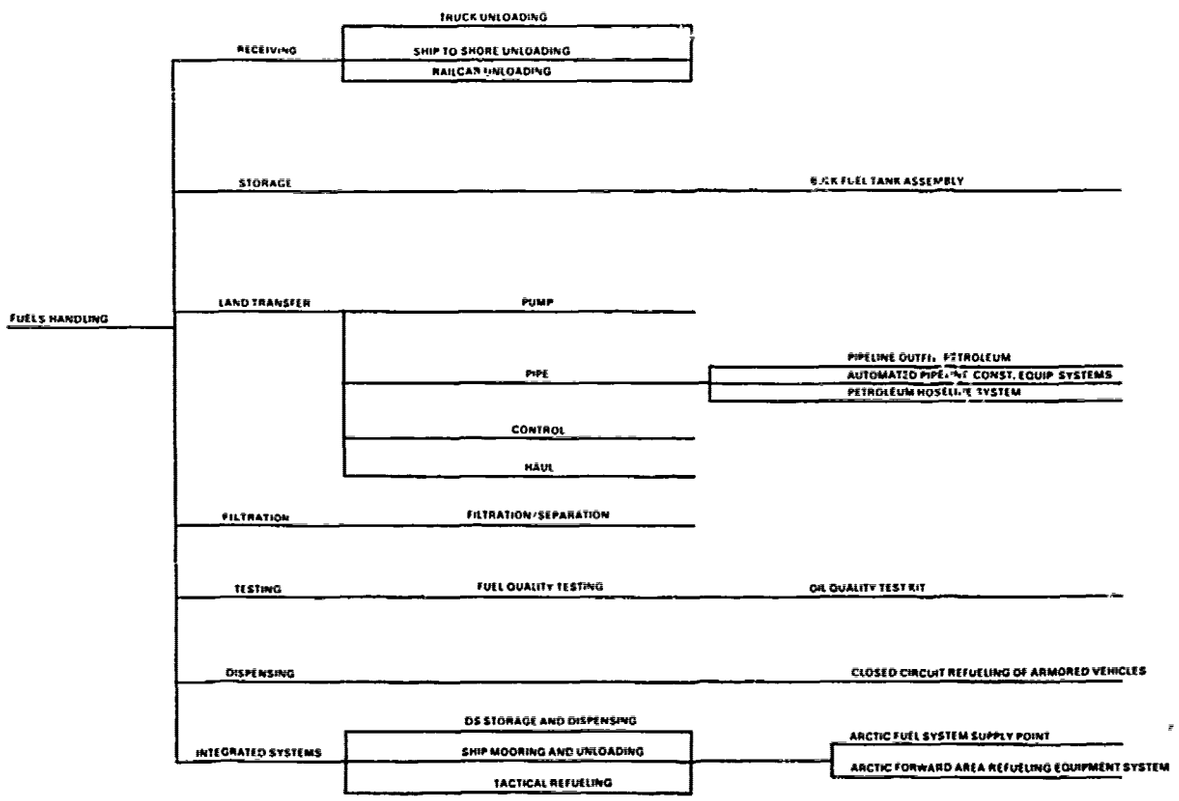


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Figure XIV-2. Summary of Fuels Handling R&D Materiel Acquisition Activities

use of existing equipment to support a rapid strike force even under ideal sea state and surf conditions.

(3) Shallow sea bottom gradients preclude the use of existing offshore mooring systems and ship-to-shore pipeline due to the excessive distance a fuel tanker must anchor offshore.

(4) Air shuttle of containerized fuel is not practical due to the large number of aircraft required as well as the corresponding airfield and off loading facilities needed on land. These will not be available in undeveloped theaters.

2. US Army is Unable to Move Adequate Amounts of Bulk Fuel Cross-Country Under Modern Integrated Battlefield Conditions

Present fuels transportation and storage equipment are unable to supply the bulk fuel in the quantities required for the future combat weaponry and transportation equipment which are under development. Pipeline systems require extensive manpower effort and lay-rates are unacceptable to keep up with the high speed tactical vehicles such as the M-1 main battle tank. The mobility potential of the combat weaponry under development is dependent upon a rapidly deployable and versatile pipeline system.

In addition to an adequate fuel transportation system, the high fuel consumption rates of combat vehicles (1.9 miles/gallon for the M-1 tank) require an extensive system of static storage tanks which can be rapidly deployed and transportable fuel containers.

3. US Army is Unable to Refuel Combat Vehicles with Adequate Safety and Efficiency Under Modern Integrated Battlefield Conditions

Present fuel dispensing equipment is inadequate for refueling the highly mobile combat vehicles and tactical equipment currently under development. This equipment requires larger quantities of fuel at faster loading rates and at greater fuel purity than ever before. The current refueling capability is limited to manually operated open port refueling. Concealment while refueling cannot be effectively accomplished at night since artificial lighting is required to prevent spillage and premature "topping off" caused by fuel foaming. Present methods of refueling are also slow, plus they introduce possible contamination in the form of dust, dirt, and moisture into the fuel. In addition, present refueling practices present a safety hazard to personnel and equipment.

Under current practice, combat vehicles must return to rear areas for refueling. This requirement decreases their battle effectiveness and at fuel consumption rates such as 1.9 miles/gallon for the M-1 tank, requires a

large amount of fuel in order to refuel. Being able to refuel at the battle station will provide for full battle effectiveness.

4. US Army Bulk Fuel Systems are Highly Vulnerable to Threat Attack Mechanisms

Bulk fuel systems are highly vulnerable to the various attack mechanisms of hostile forces as well as guerrilla and terrorist attack. Fuel in fabric tanks is highly susceptible to catastrophic disaster which can be caused by a small tear induced by a bullet or knife. If the slit exceeds a critical length the tear will propagate and cause a catastrophic failure. One incendiary projectile could destroy a fuel tank and jeopardize an entire tank farm. Remote sections of pipelines are easily sabotaged. Pump stations and dispensing systems are highly vulnerable to attack and accidental catastrophes. Personnel safety, aborted missions and pollution of the environment are hazards of this vulnerability.

F. FUELS HANDLING SCIENCE AND TECHNOLOGY PROGRAM

1. Discussion

In response to the deficiencies identified above, a variety of S&T efforts have been initiated. These initiatives show significant promise for advancing the capabilities of Military Fuels Handling.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed in Section E. A graphic display illustrating the relationships and schedule is provided at Figure XIV-3.

a. LOTS Capability, Military Air Cushion Bulk Fuel Vehicle

1) Feasibility Determination

This effort will be an analytical analysis of the feasibility and military worth of air cushion vehicles for over-the-beach delivery of bulk fuels. Specific applications will be where beach gradient precludes the use of pipelines, and in the initial phases of amphibious operations before ship-to-shore pipelines and other means of supplying fuel can be deployed. The occurrences of beaches where the bottom gradient precludes the installation of pipelines, according to the proper scenarios, will be considered in assessing the military worth of the system.

2) Characteristics Determination

This effort will be the establishment of air cushion vehicle characteristics to best meet military requirements. Operational and technical parameters will be established. The result of this effort will be used as the basis for a full-scale development program.

b. LOTS Capability, Underwater Fuel Storage System

1) Feasibility Study

This effort will be an analytical evaluation of the feasibility of using underwater storage of bulk fuel for support of amphibious operations. Underwater storage of bulk fuel will be considered as a supplement to the air cushion vehicle. Design parameters will be established.

2) Feasibility Test

This effort will be the design of an optimum underwater fuel storage system. The testing of a scaled down version will be accomplished to validate the analysis of this high risk item.

c. Tactical Cross-Country Fuel Capability-Tactical Fuel Distribution System

1) Rapidly Deployable Pipeline Feasibility

This effort will be an in-depth analysis and a preliminary configuration of an optimum cross-country pipeline system which can be rapidly deployed. The effort will include a preliminary configuration of the pipeline installation equipment required to accomplish installation at a rate of 30 KM/day.

2) Rapidly Deployable Storage System Feasibility

This effort will emphasize the physical configurations of fuel storage tanks and transportable fuel containers, and the materials of construction. Installation equipment requirements and procedures will be explored. A preliminary configuration of any special installation equipment will be provided. Alternative approaches relative to materials and installation equipment will be considered. Scaled-down versions will be procured and tested.

d. Tactical Refuel Capability-Tactical Refueling System

1) Closed Circuit Refueling Feasibility

This effort will be an analytical evaluation to identify and evaluate alternative approaches for providing a closed-circuit rapid vehicle refueling capability. Recommendations will be provided as to the preferred approach and the required operational and technical parameters of the system. The feasibility and military worth of the recommended approach will be thoroughly demonstrated.

2) Bulk Fuel Carrier Combat Effect Evaluation

This effort will be an analytical evaluation of the feasibility of using bulk fuel carriers in a combat environment. An evaluation of the vulnerability of

the different carriers to various attack mechanisms will be thoroughly demonstrated.

3) Combat Refuel Evaluation

This effort will be an analysis of methods for refueling tanks and other combat vehicles in a combat environment with minimum personnel exposure. Recommendations will be provided on increased refueling rates and special fuel carriers. The feasibility of remote control of all facets of refueling operation will be accomplished.

e. Bulk Fuel Vulnerability - High Survivability Bulk Storage System

1) Evaluation and Demonstration of Resistant Construction Materials

This effort will be an analytical evaluation for providing improved resistance to various attach mechanisms. The vulnerability of current bulk fuel systems (pipelines, hoselines, fuel storage tanks, pump stations, and dispensing systems) will be used as a baseline for evaluating the military worth of hardened systems and system components. This effort will encompass the following:

(1) The development of advanced materials with improved tear resistance for coated fabric fuel storage tanks. This effort will be a bench demonstration of the new coatings, materials, and other equipment hardening techniques resulting in the above analysis.

(2) The development of flame extinguishing coatings compounds for coated fabric fuel storage tanks to reduce the vulnerability to incendiary projectiles.

(3) The development of ablative coating compounds to neutralize the effects of high altitude nuclear blasts.

(4) The development of an earth sealing spray for containing fuel within a berm in the event of rupture of a coated fabric fuel storage tank.

2) Test Scale Model

Scaled model tests will be conducted to confirm the concepts developed by the analysis and demonstration to insure technical soundness and cost effectiveness of this high technology activity.

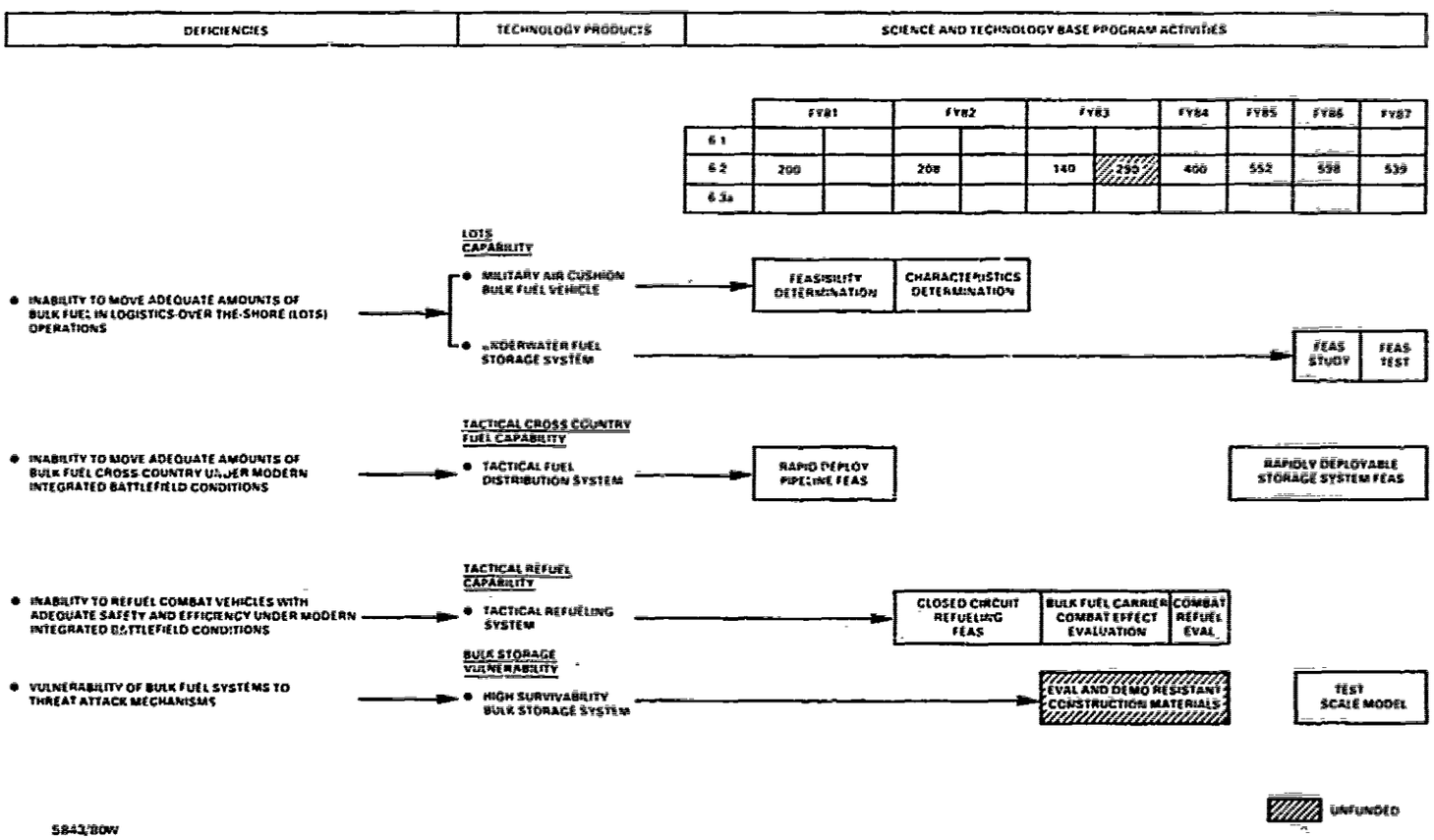


Figure XIV-3. USAMERADCOM Fuels Handling Science and Technology Base Program Activities

CHAPTER XV
MATERIALS HANDLING EQUIPMENT

CHAPTER XV
MATERIALS HANDLING EQUIPMENT

A. MILITARY SIGNIFICANCE AND NEED

Materials handling equipment provides ammunition and other vital supplies at the increased rates required by the modern integrated battlefield within the constraints facing the US Army.

B. FUNCTIONAL CHARACTERISTICS

Materials Handling Equipment in the Army can be divided into three major functional areas.

1. Warehousing and Depot Operations

This function involves the storing and handling of material as part of a major supply operation. This function may be performed inside a closed building or in an open yard depending on the nature of the material and storage space available.

2. Containerization

This function involves the loading and unloading, moving and transporting, and special operations relative to the use of containers (20 ft. and 40 ft. MILVANS, and ISO containers) for storing and transporting material. It includes the multi-modal transfer of containers and the various types of mobile equipment used for that purpose.

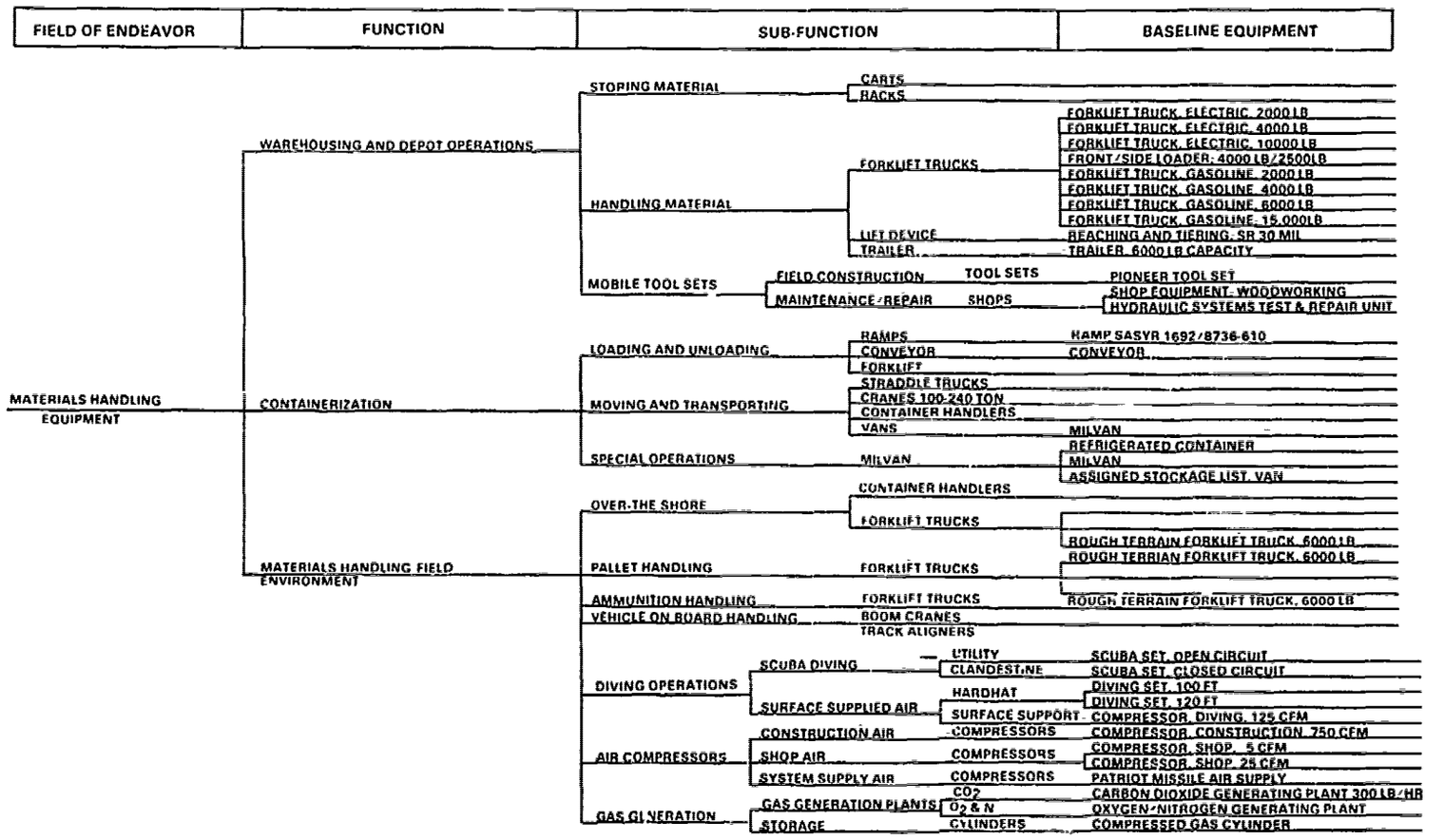
3. Materials Handling Field

This function involves over-the-shore operations (LOTS), forward area pallet handling, and container handling. Included also are air compressors for supplying air under pressure for construction, shop use, and system supply (other than diving systems); and gas generation equipment for generating CO_2, O_2, N, etc. gases, as well as replenishment of cylinders for gas storage.

C. CURRENT CAPABILITY

The US Army's current and projected near-term capability to meet its requirements in Materials Handling Equipment consists of the baseline equipment shown in Figure XV-1. Descriptions of each of these items are presented in Volume XIII of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing materials handling capabilities are summarized below.

Equipment listed in Figure XV-1 is only a small representative sample of the equipment for which the Mechanical and Construction Equipment Laboratory has responsibility. The principal item of equipment used for materials handling is the fork lift truck which is available in a wide-range of



NOTE EQUIPMENT LISTED IS ONLY A SMALL REPRESENTATIVE SAMPLE OF THE EQUIPMENT FOR WHICH THE MECHANICAL AND CONSTRUCTION LABORATORY HAS RESPONSIBILITY

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Figure XV-1. Baseline Equipment Summary for Materials Handling Equipment

sizes and a variety of power drives and configurations. Forklift trucks are designed for rough terrain operations as well as for prepared surfaces. In addition to the many different types of forklift trucks available, many other special purpose lifting and carting devices are used. Among these are industrial trucks, tractor-trailers, container handlers, cranes, ramps and conveyors.

D. ACQUISITION ACTIVITIES

Figure XV-2 identifies current R&D materiel acquisition activities generated from 6.3b, 6.4, MACI, and CNDI programs. At present, these are focused on ammunition replenishment, ammunition stockage materials handling equipment, and a container logistic system. The activities will provide technology to support the operational system needs to resupply and store ammunition and support container-based logistics. Figure XV-3 shows a rough terrain forklift truck which is being acquired for improved materials handling capability in unimproved areas.

E. CURRENT CAPABILITY DEFICIENCIES

A comparison of current materials handling capability and ongoing acquisition activities versus current needs has revealed the following three major deficiencies.

1. US Army Does Not Have Adequate Technology to Support the Operational Need to Replenish Ammunition in the Firing Units Battle Position

Forward ammunition resupply from an ammunition supply point, the combat user's source of ammunition, is labor intensive. This forward resupply of ammunition is the combat unit's responsibility and is accomplished using their equipment and personnel. Their ability to carry out this responsibility is further exacerbated by the advent of new weapon systems with higher rates of fire (i.e., Abrams Tank, Enchanced Self-Propelled Weapon System), by the requirement to fight in an NBC Environment (which alone dictates the use of MHE to extend the period of time personnel can function in their NBC Protective Gear); and by the advent of weapon systems such as the MLRS (Multiple Launch Rocket System) which requires new MHE for replenishment because of its configuration. Introducing MHE into the forward combat area is not without risk. Ammunition must be transferred from one vehicle to another in a combat environment. This environment includes rough terrain, night operations, climatic extremes, NBC, and the constraints imposed by the design and deployment of combat vehicles.

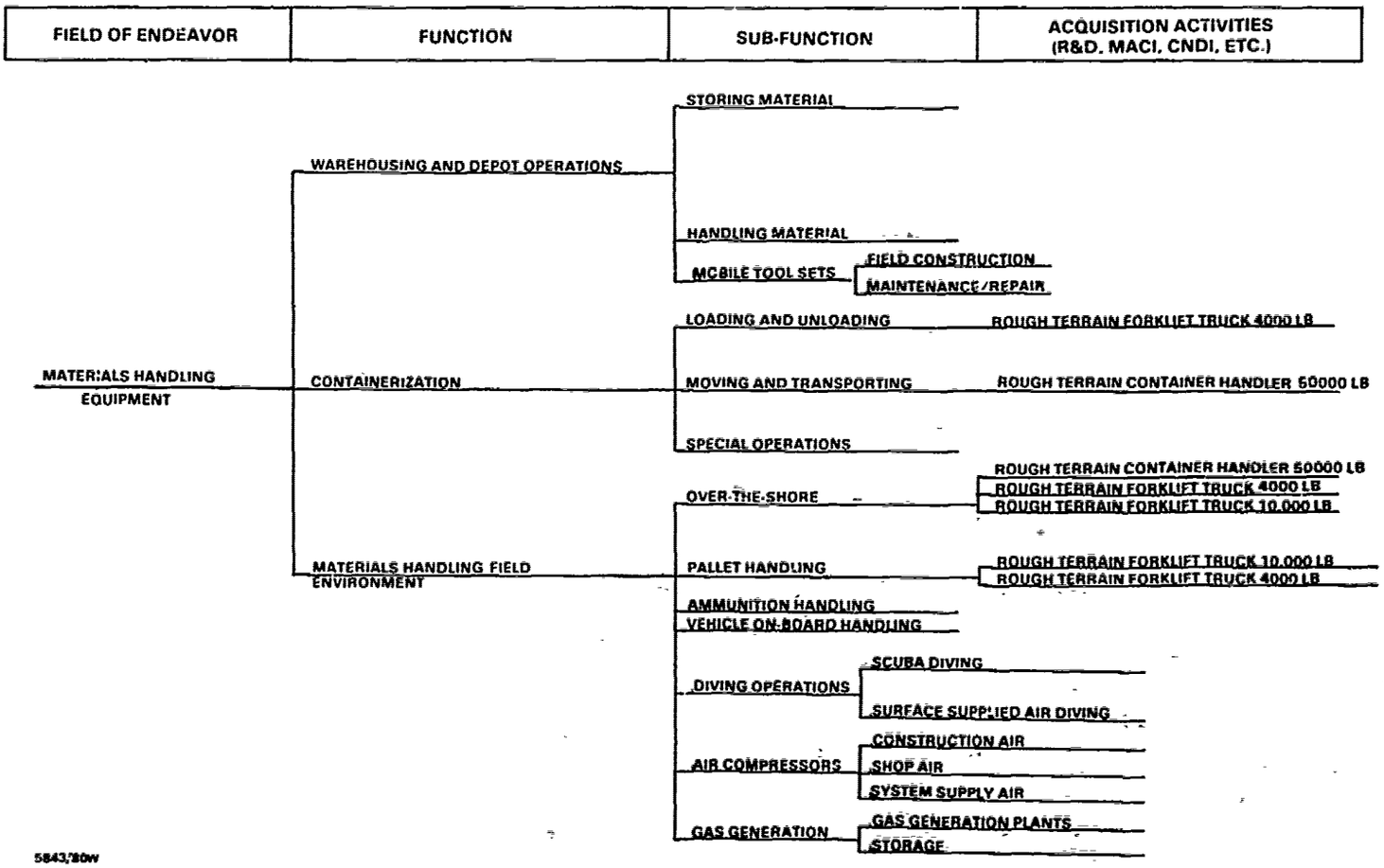

Figure XV-2. Summary of Materials Handling Equipment R&D Materiel Acquisition Activities

Figure XV-3. Rough Terrain Forklift

2. US Army Does Not Have Adequate Technology to Support the Operational Need to Outload Ammunition Storage Facilities in the Theater of Operations

a. The combat unit must be capable of autonomously accomplishing its mission including the MHE required to outload from the unit's ammunition prestocked point (PSP). This is the unit's initial basic supply of ammunition. Unique requirements for MHE are prevalent including a long standby before use, high reliability for critical one-time use and low unit cost commensurate with a throw away item since the PSP will not normally be reused.

b. In the European Scenario, ammunition and missiles must begin to flow from the theater war reserves forward to the combat units before the units deplete their basic load. This intheater war reserve was placed into storage during peacetime taking advantage of existing available storage space. Extracting this ammunition requires three items of MHE with three operators. The resource restraints imposed by a contingency situation makes this an impractical operation. Unventilated storage space precludes the use of internal combustion powered MHE due to environmental contamination. Also the stringent safety requirements for handling ammunition in an enclosed igloo must be satisfied by MHE used.

Missiles, because of their length, pose additional problems for rapidly outloading the magazines. MHE is not available in the commercial sector which can satisfy the requirement to handle missiles inside, move them through narrow doors and place them on transport vehicles.

3. US Army Does Not Have Adequate Technology to Support Container Based Logistics Systems Under Battlefield Conditions in the Absence of Peacetime Commercial Support Facilities

The advent of containerization as the primary method of overseas cargo movement within the commercial supply distribution system has created problems within the military system. During peacetime these problems are not evident because the military utilizes the existing commercial system and its volume of movement does not create any shortfall within this system.

Present doctrinal planning has avoided, by assumption, many wartime problems by such philosophies as "host nation agreement" and primary concentration on the European Theater as the major area of potential wartime concern.

Current events appear to be changing this concentration of effort in the European environment. Not only must we continue to support Europe but we must develop a capability within the Middle East as well. The Rapid Deployment Force is the latest excursion from a scenario strictly European in character.

To meet this changing philosophy, the Army must investigate new technologies which allow sustained container operation in adverse areas and under conditions which are

not dependent on the availability of large commercial container handling facilities.

Investigations must be undertaken which will provide lightweight, easily transported container handling equipment for forward area use and a renewed emphasis on the development of handling equipment for Logistics-Over-The-Shore (LOTS) operations.

Specific materials handling problems must also be addressed as they relate to new Rapid Deployment Force requirements.

F. MATERIALS HANDLING EQUIPMENT SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In response to the deficiencies cited above, several specific MERADCOM S&T efforts have been initiated. These include the following projects.

a. Forward Ammunition Resupply

This project will address the introduction of MHE into forward combat units to handle ammunition. This MHE must be compatible with the unique requirements imposed by the forward combat area. The Army must investigate and develop the technology required to provide MHE compatible with armored vehicular interfaces, their interiors, the NBC environment, the combat mission requirement and the combat environment and terrain. This approach is required to develop the technology base to the extent necessary to insure MHE insertion into the early phases of weapon system development (e.g., ESPAWS, Tank, FAASV and AFARV). Otherwise, the freezing of weapon design allows only sub-optimal MHE alternatives to be applied.

b. Materials Handling Equipment in the Theater of Operations

This project will address the rapid outloading of ammunition and missiles in the Theater of Operations during transition to war both for the combat units basic load and for follow on resupply pending full scale supply operations. These stocks were emplaced in long-term storage in order to take advantage of all available storage space during peacetime. The Army must investigate new technologies which will allow around-the-clock MHE operation in an unventilated igloo and on adjacent improved hardstands. Technology must also be investigated for long term standby, short term use of low cost MHE. This technology investigation also responds to the requirement to handle missiles in addition to ammunition pallets. This technology base effort is required to provide Theater of Operations MHE compatible with identified transition-to-war requirements.

c. Supply Distribution in a LOTS and RDF Environment

This project will address changing deployment philosophies which have fostered the development of a Rapid Deployment Force (RDF). To respond the Army must investigate new technologies which will allow for sustained container operation in advance areas and under conditions which may not have the advantage of large commercial container handling facilities. Investigations must be undertaken which will provide lightweight, easily transported container handling equipment for forward area use. A renewed emphasis on the development of handling equipment for Logistics-Over-The-Shore (LOTS) operations must be imposed. This approach will overcome the present shortfall created by filling an identified gap in these areas with large and difficult to deploy items of commercial hardware, which will require extensive support assets to insure delivery to forward areas.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the associated individual program activities have been specifically instituted or planned to relieve the deficiencies discussed above in Paragraph E. Figure XV-4 illustrates the relationship and schedule of these activities and products.

a. Combat Position Ammunition Resupply System

The products of this S&T effort are the development and assessment of a variety of system concepts which deal with the delivery of a continuous supply of ammunition to forward combat units in a manner which is compatible with the environment, the terrain, and the vehicles employed; and which meets combat mission requirements. System concept definition and assessment will be followed by a demonstration of the feasibility of selected concepts. A demonstration of an integrated system will be conducted following the acceptance of one or more concepts demonstrated.

b. Ammunition Igloo Outload System

This effort will devise and assess system concepts for rapid outloading of basic unit load and war reserve stocks of ammunition and missiles in the Theater of Operations. New weapon systems introduce different materials handling requirements which become particularly critical during a peacetime-to-wartime transition. Upon selection of particular concepts which offer promise for safer and more efficient handling, a demonstration of the feasibility of these concepts will be conducted. Design specifications for systems meeting requirements will then be prepared.

c. Battlefield Container Support Systems

This effort will devise and assess system concepts for handling MILVAN and commercial containers under a wide-range of operating conditions. The RDF concept has promoted the need for extensive logistic support in undeveloped port areas and with relatively primitive support. Increased use of containers in the Army logistic system introduces many non-traditional MHE demands which must be met with new technologies and innovation. Following a concept definition of a suitable system for battlefield, including LOTS container support, a feasibility demonstration of the concept will be conducted.

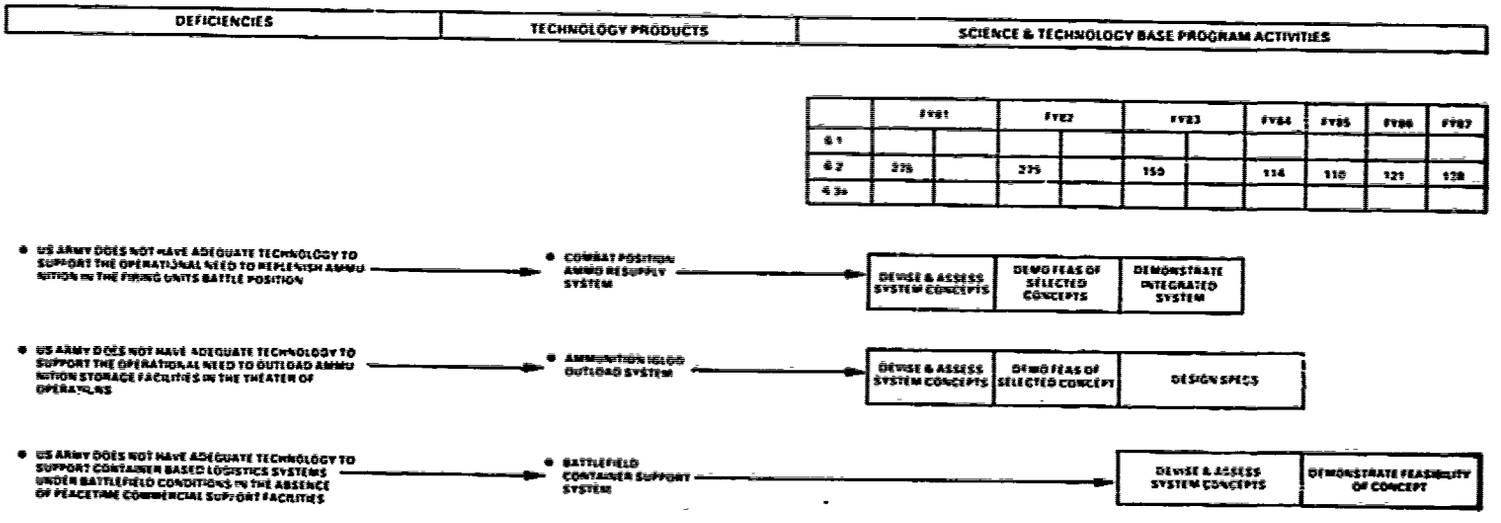

Figure XV-4. USAMERADCOM Materials Handling Equipment Science and Technology Base Program Activities

CHAPTER XVI
MARINE CRAFT

CHAPTER XVI
MARINE CRAFT

A. MILITARY SIGNIFICANCE AND NEED

Army Marine Craft deliver all sealift logistic support into the theater of operations where piers, wharves, and prepared facilities are unavailable. Large scale US military and rapidly deployable force land operations cannot be sustained without this support.

B. FUNCTIONAL CHARACTERISTICS

Army Marine Craft can be divided into the following three major functional areas:

1. Logistics Over The Shore (LOTS)

This function involves the offloading of cargo from various types of ocean-going transport ships; including container, break-bulk, liquid bulk and dry bulk, offshore to bare beach locations on shore and inland for redistribution and use. Also involved are the movement of cargo through surf and across beach areas to inland points under all environmental conditions. It includes heavy lift lighterage to support current operational requirements (i.e., M-1 tanks, 40 ft. MILVAN and ISO containers, CHITO, and other outsized and heavy weight systems).

2. Coastal, Harbor and Inland Water Operations (CHI)

This function involves the movement of personnel, cargo, equipment and supplies throughout coastal regions, inland waterways and harbors; movement of cargo ships into established port facilities; transfer of cargo in unimproved or augmented ports; providing command, control, patrol and support in port operations and inland waters; and providing reconnaissance and assault (15 man inflatable boat) in connection with combat operations.

3. Marine Support Systems

This function encompasses a variety of support operations associated with the marine environment or the water-land interface. The following categories are included:

(1) Provide POL/supplies to fleet operations
(2) Provide maintenance services to the marine fleet
(3) Provide heavy lift and offload capability
(4) Marine inspection
(5) Salvage operations
(6) Terminal operations within a port or beach complex
(7) Barge and small boat propulsion
(8) Fire fighting
(9) Training
(10) Ferry

C. CURRENT CAPABILITY

The current and projected near term capability of the Army to meet its requirements for marine craft is represented by baseline equipment in Figure XVI-1. Descriptions of each of these items are presented in Volume XI of the MERADCOM DIGEST OF EXISTING AND DEVELOPMENTAL ITEMS OF EQUIPMENT AND SYSTEMS. The major existing items of equipment in the three major functional areas are summarized below.

The capability for offloading container ships offshore and for transferring cargo from a lighter to shore is provided by two basic types of pier barges, A DeLong and B DeLong assuming a compatible beach gradient. A modified B DeLong pier barge, employing a 350 ton mobile crane, comprises a Temporary Container Discharge Facility (TCDF) for loading and offloading non selfsustaining container ships. Amphibious lighters, ACV lighters, landing craft, beach discharge lighters and causeway pontoon sections are used to transport cargo from open water through surf or across a beach to staging points inland. A variety of barges (deck or liquid cargo, refrigerator, crane) are used to move or transfer cargo and assist in salvage operations while several different types of boats (T-boats, Q-boats, J-boats and landing craft) are used to transfer personnel and equipment, conduct marine inspection, and provide command/control support. Several types of tug boats of varying power capacity are used for towing barges and or moving larger ships in restricted waterways. Two types of inflatable boats (3 man and 15 man) are used with outboard motors for reconnaissance and for supporting assault operations. Freight supply vessels and liquid cargo vessels/barges are used to supply petroleum oils and lubricants and other supplies to fleet operations. Heavy lift and offload capability in support of all types of marine operations are provided by 60 ton and 100 ton crane barges. A floating repair shop provides maintenance services to the marine fleet. To support terminal operations within a port or beach complex a range of specialized cargo handling equipment is available in sets. Miscellaneous functions such as fire fighting, training and personnel movement are performed by specialized craft of modified design or configuration.

D. ACQUISITION ACTIVITIES

Current MERADCOM R&D materiel acquisition activities generated from 6.3b, 6.4, MACI and CNDI programs are shown in Figure XVI-2. At present these are focused on the acquisition and/or adaptation of commercial tug boats, a commercial coastal/harbor/inland waterway service (CHI) boat, and

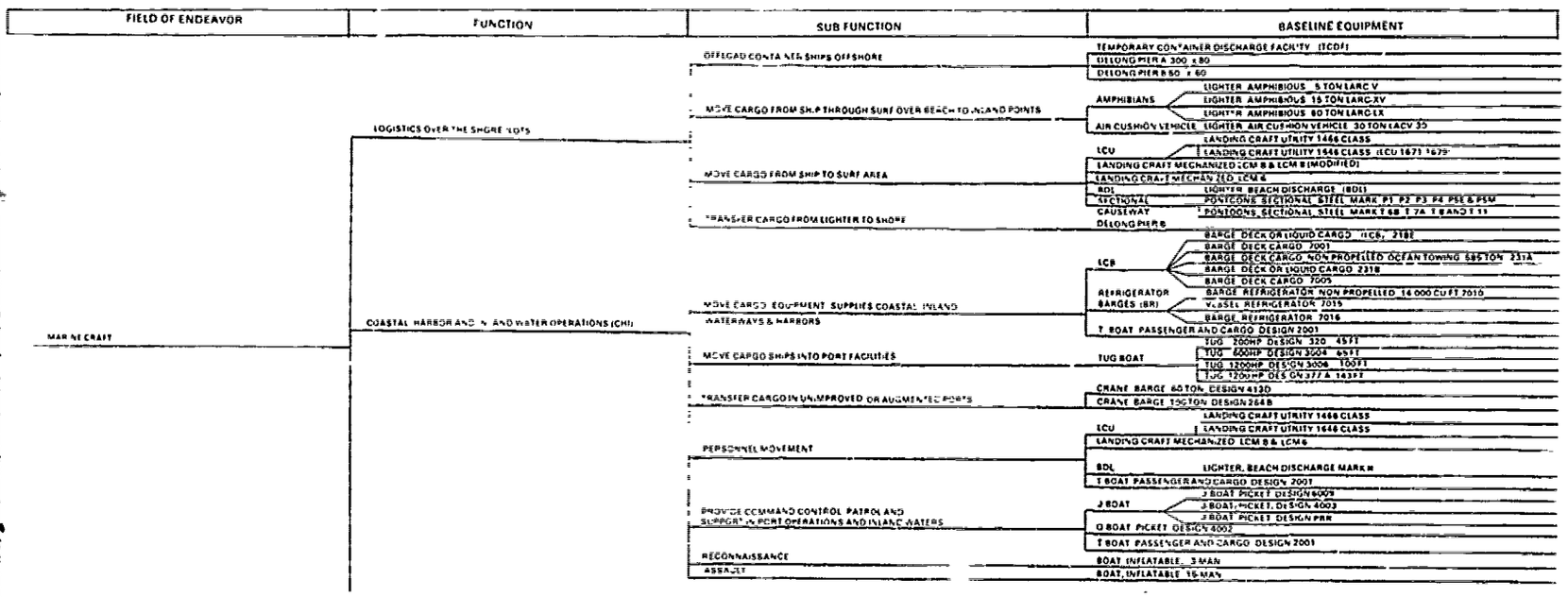

Figure XVI-1. Baseline Equipment Summary for Marine Craft

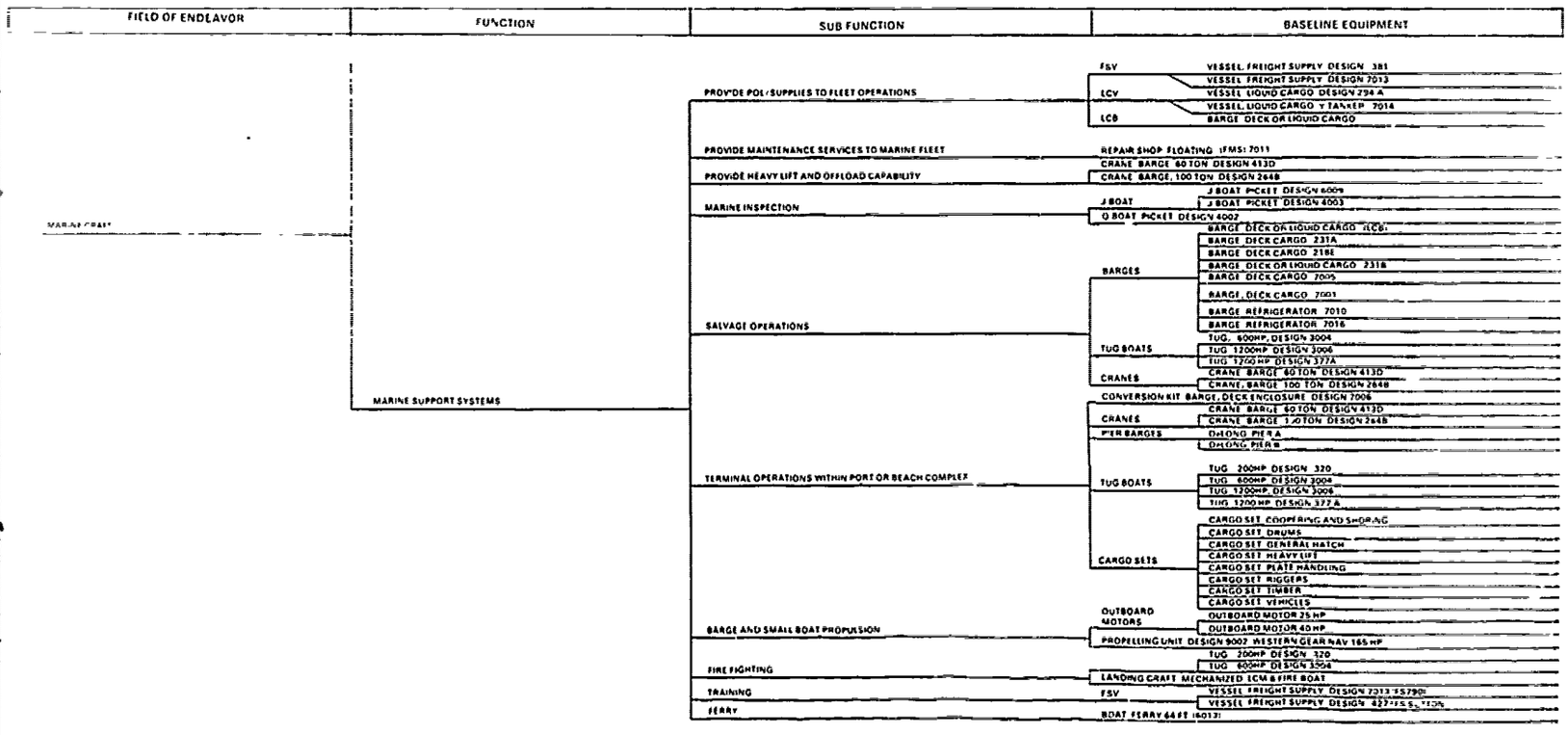

Figure XVI-1. Baseline Equipment Summary for Marine Craft (Continued)

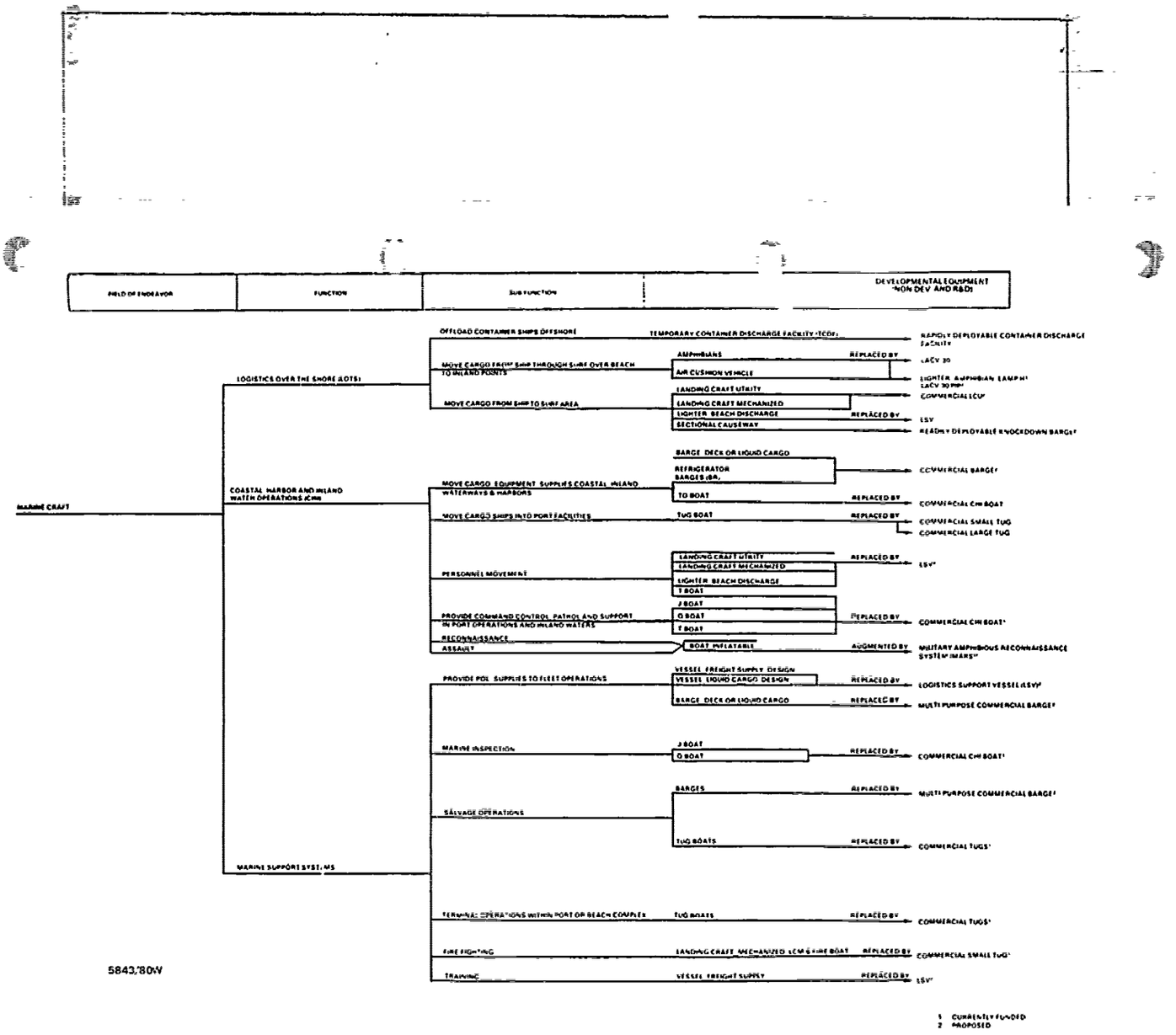

Figure XVI-2. Summary of Marine Craft R&D Materiel Acquisition Activities

and a military amphibious reconnaissance system (MARS) to replace certain items of aging and operationally deficient marine craft.

Two classes of tug boats are contemplated: a large tug not more than 150 feet long that will be capable of assisting in docking and undocking the largest ships likely to be encountered in resupply operations; and a small tug not more than 75 feet long that will be capable of moving floating crane and towing up to four standard barges fully loaded. The CHI boat will provide command and control, passenger and light cargo transport and will have a maximum length of 60 feet and maximum draft of 6 feet. It is planned to replace T, J, and Q boats now in service.

The Military Amphibious Reconnaissance System (MARS) is planned to augment existing inflatable boats. The MARS will carry a crew of up to seven persons with individual equipment on reconnaissance missions.

Several additional acquisition activities are in progress but are currently unfunded. Among these are:

(1) Rapidly Deployable Container Discharge Facility (RDCDF)
(2) Amphibious Lighters, LAMP H
(3) LACV-30 Product Improvement Program
(4) Commercial Landing Craft (LCU)
(5) Logistic Support Vessel (LSV)
(6) Readily Deployable Knockdown Barge
(7) Multi-purpose Commercial Barge.

Figure XVI-3 shows the LACV-30 Air Cushion Lighter presently under acquisition by the Army.

E. CURRENT CAPABILITY DEFICIENCIES

Two major deficiencies are noted to exist in the Army Marine Craft program.

1. US Army lighterage (ship to shore transport) is inadequate to support current heavy lift operational requirements (i.e., M1, 40' MILVAN and ISO containers, and other outsized and heavy weight systems).

The arrival of sea-going container and other cargo ships at offshore points in a Logistics-Over-the-Shore operation requires the offloading and transshipment of containers and cargo across the shore to inland points as rapidly as possible. Currently-used amphibious lighterage for heavy lift is inadequate with respect to deployment, productivity, and required heavy lift capability.

2. US Army Capability To Deploy Container Ship Discharge Facilities and Lighterage (Ship-to-Shore Transport) is Inadequate to Support Operational Requirements

The arrival of fast, seagoing container ships at offshore points in a Logistics-Over-the-Shore operation

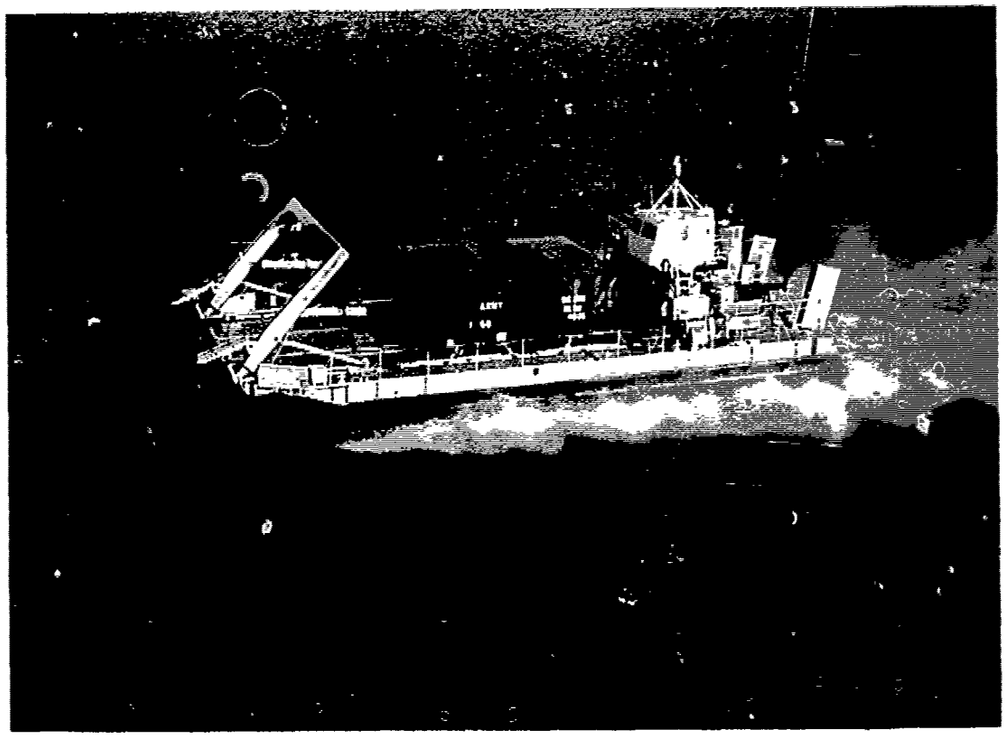

Figure XVI-3. LACV-30 Air Cushion Lighter

requires the offloading of containers from the ship to lighterage systems for transshipment to the shore or inland points. The container discharge facility currently in use is temporary in nature and requires either heavy lift ships (very few of which are available) or slow speed towing which severely limits deployability. The rapid deployability advantage of high speed container ships and the deck loadability of the first generation of air cushion lighterage (LACV 30) are severely derogated.

F. MARINE CRAFT SCIENCE AND TECHNOLOGY BASE PROGRAM

1. Discussion

In addressing the deficiencies cited above, a number of S&T efforts have been initiated. These efforts are designed to take maximum advantage of US Navy and commercial developments in this area, and to adopt state-of-the-art technology in new designs. New materials, propulsion systems and construction techniques offer considerable promise for alleviating the limitations imposed by current equipment. The introduction of containerized cargo in the form of 40' MILVANS and ISO containers, as well as the need to lift and transfer other outsized and heavy weight systems at sea under all environmental conditions and transport them through surf or across a beach pose a serious limitation in operational capability. Wider use of containerized cargo contributes to both of the deficiencies cited but impacts on the operational requirement in different ways. In the one case, upgrading of the LACV 30 by larger propulsion equipment, weight reduction methods and more efficient air cushion design through the Product Improvement Program will enhance performance. Design of a new Amphibious Lighter, the LAMP H, will upgrade the weight carrying capability from 60 tons to over 90 tons. The other major deficiency, that of a container ship discharge facility for deployment to forward areas which lack suitable container handling equipment is being investigated through the process of concept synthesis and assessment and will lead to a system definition. The proposed RDCDF may take advantage of surface effect or air cushion principles to permit movement of a container discharge facility at the speed of container ships.

2. Science and Technology Base Program Products and Activities

The following S&T Base Program Products together with the individual program activities have been specifically instituted or planned to relieve the deficiencies discussed in paragraph E. The relationship and schedule of these activities are illustrated in Figure XVI-4.

Increased mobility and reduction of turnaround time utilizing air cushion technology will assure greater

productivity and greater lift capability. Lighter system dry weight and modularization also offer dramatic increase in deployment capability. Further, increased cargo throughput per vessel and mobility will reduce the number of vessels required to perform assigned missions.

a. Heavy Lift Amphibious Lighter

This S&T effort consists of two separate elements: (1) A concept synthesis and assessment followed by the development of a system definition for a heavy lift (80-100 tons) amphibious lighter, (2) Upgrade of LACV-30 through Product Improvement Program (PIP). The proposed program will investigate a variety of concepts to determine technical feasibility, cost and operational effectiveness. High technical and operational risk areas will be identified and definition of a system outlined. The ultimate objective is to demonstrate technical feasibility and pursue a development or military adaptation of commercial items (MACI) program. The technical product/output of this activity will be: Identification/description of operational and technical needs and approaches to meet the needs; synthesis, evaluation, and recommendations for future concepts and actions; upgrade of the LACV-30 system to determine if it can be made to provide Logistics-Over-The-Shore (LOTS) for heavy military material such as tanks and self-propelled guns.

b. Rapidly Deployable Container Discharge Facility (RDCDF)

This S&T effort is being conducted on an inter-service basis with initial investigation being conducted by the Navy. The work is not yet funded by the Army. The investigation of surface effect (air cushion) technology toward overcoming this problem is the key to this proposed program. Surface effect technology used in the high speed USN Surface Effect Ship (SES) will be analyzed and applied to the movement (towing) of a container discharge facility at the speed of container ships. Technical and operational risks will be identified, technical feasibility determined, and a concept formulated to include major component systems definition. The ultimate objective is to demonstrate technical feasibility and pursue a development effort to field such a system.

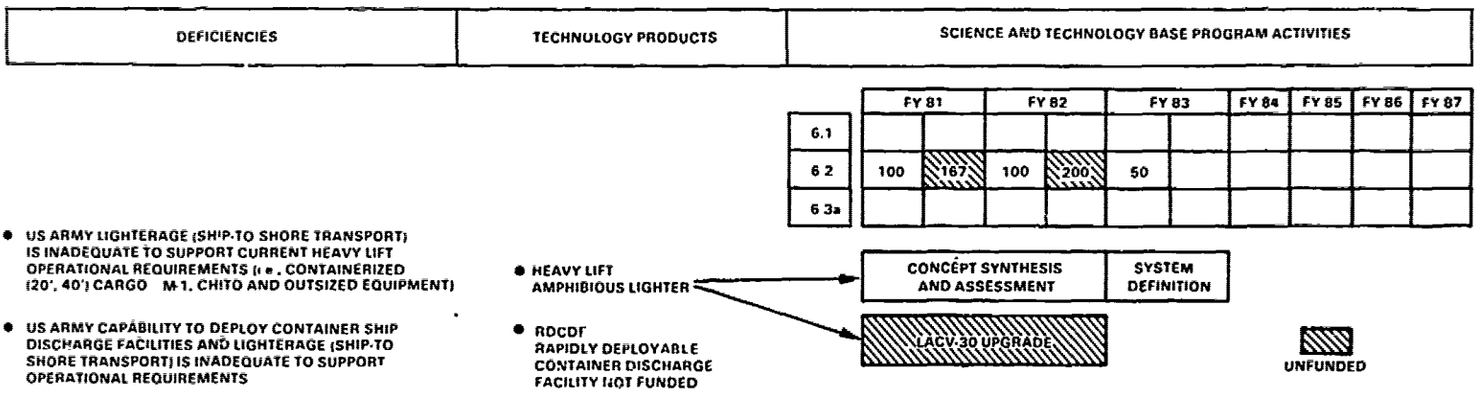

Figure XVI-4. USAMERADCOM Marine Craft Science and Technology Base Program Activities